JRC Technical Notes

Case Study – United Kingdom

Sustainable Agriculture and Soil Conservation (SoCo Project)

Lynda Deeks, Helena Posthumus, Jane Rickson, Ian Fenn, Catherine Bowyer, David Baldock, Nicole Heyn

EUR 24131 EN/10 - 2009

JRC
EUROPEAN COMMISSION

ipts
Institute for Prospective Technological Studies

ies
Institute for Environment and Sustainability

Case Study United Kingdom

Sustainable Agriculture and Soil Conservation (SoCo Project)

The project 'Sustainable Agriculture and Soil Conservation (SoCo)' is a pilot project commissioned by the Directorate-General for Agriculture and Rural Development, in response to the request of the European Parliament (Administrative Arrangement AGRI-2007-336).

Authors:
Lynda Deeks, Helena Posthumus, Jane Rickson[1], Ian Fenn, Catherine Bowyer, David Baldock[2], Nicole Heyn[3]

Editors:
Stephan Hubertus Gay, Monika Schmidt[4], Katrin Prager[5]

1 Cranfield University, Natural Resources
2 Institute for European Environmental Policy
3 Leibniz Centre for Agricultural Landscape Research (ZALF)
4 European Commission, Joint Research Centre (JRC), Institute for Prospective Technological Studies (IPTS)
5 Humboldt-Universität Berlin, Faculty of Agriculture and Horticulture

The mission of the JRC-IPTS is to provide customer-driven support to the EU policy-making process by developing science-based responses to policy challenges that have both a socio-economic as well as a scientific/technological dimension.

European Commission
Joint Research Centre
Institute for Prospective Technological Studies

Contact information
Address: Edificio Expo. c/ Inca Garcilaso, 3. E-41092 Seville (Spain)
E-mail: jrc-ipts-secretariat@ec.europa.eu
Tel.: +34 954488318
Fax: +34 954488300

http://ipts.jrc.ec.europa.eu
http://www.jrc.ec.europa.eu

JRC 55639

EUR 24131 EN/10
ISBN 978-92-79-14959-7
ISSN 1018-5593
DOI 10.2791/39515

Luxembourg: Office for Official Publications of the European Communities

Printed in Spain

Preface

Agriculture occupies a substantial proportion of European land, and consequently plays an important role in maintaining natural resources and cultural landscapes, a precondition for other human activities in rural areas. Unsustainable farming practices and land use, including mismanaged intensification and land abandonment, have an adverse impact on natural resources. Having recognised the environmental challenges of agricultural land use, in 2007 the European Parliament requested the European Commission to carry out a pilot project on 'Sustainable Agriculture and Soil Conservation through simplified cultivation techniques' (SoCo). The project originated from close cooperation between the Directorate-General for Agriculture and Rural Development (DG AGRI) and the Joint Research Centre (JRC). The JRC's Institute for Prospective Technological Studies (IPTS) coordinated the study and implemented it in collaboration with the Institute for Environment and Sustainability (IES). The overall **objectives of the SoCo project** are:

(i) to improve the understanding of soil conservation practices in agriculture and their links with other environmental objectives;

(ii) to analyse how farmers can be encouraged, through appropriate policy measures, to adopt soil conservation practices; and

(iii) to make this information available to relevant stakeholders and policy makers EU-wide.

In order to reach a sufficiently detailed level of analysis and to respond to the diversity of European regions, a case study approach was applied. Ten case studies were carried out in Belgium, Bulgaria, the Czech Republic, Denmark, France, Germany, Greece, Italy, Spain and the United Kingdom between spring and summer 2008. The case studies cover:

- a screening of farming practices that address soil conservation processes (soil erosion, soil compaction, loss of soil organic matter, contamination, etc.); the extent of their application under the local agricultural and environmental conditions; their potential effect on soil conservation; and their economic aspects (in the context of overall farm management);
- an in-depth analysis of the design and implementation of agri-environmental measures under the rural development policy and other relevant policy measures or instruments for soil conservation;
- examination of the link with other related environmental objectives (quality of water, biodiversity and air, climate change adaptation and mitigation, etc.).

The results of the case studies were elaborated and fine-tuned through discussions at five stakeholder workshops (June to September 2008), which aimed to interrogate the case study findings in a broader geographical context. While the results of case studies are rooted in the specificities of a given locality, the combined approach allowed a series of broader conclusions to be drawn. The selection of case study areas was designed to capture differences in soil degradation processes, soil types, climatic conditions, farm structures and farming practices, institutional settings and policy priorities. A harmonised methodological approach was pursued in order to gather insights from a range of contrasting conditions over a geographically diverse area. The case studies were carried out by local experts to reflect the specificities of the selected case studies.

This Technical Note is part of a series of ten Technical Notes referring to the single case studies of the SoCo project. A summary of the findings of all ten case studies and the final conclusions of the SoCo project can be found in the **Final report on the project 'Sustainable Agriculture and Soil Conservation (SoCo)'**, a JRC Scientific and Technical Report (EUR 23820 EN – 2009). More information on the overall SoCo project can be found under http://soco.jrc.ec.europa.eu.

BE - Belgium	**West-Vlaanderen** (Flanders)
BG - Bulgaria	**Belozem** (Rakovski)
CZ - Czech Republic	**Svratka river basin** (South Moravia and Vysočina Highlands)
DE - Germany	**Uckermark** (Brandenburg)
DK - Denmark	**Bjerringbro and Hvorslev** (Viborg and Favrskov)
ES - Spain	**Guadalentín basin** (Murcia)
FR - France	**Midi-Pyrénées**
GR - Greece	**Rodópi** (Anatoliki Makedonia, Thraki)
IT - Italy	**Marche**
UK - United Kingdom	**Axe and Parrett catchments** (Somerset, Devon)

Table of content

List of tables

List of figures

ACRONYMS

DAS	The Agricultural Development and Advisory Service
AEM	Agri-environment measure
CC	Cross-compliance
CSF	Catchment Sensitive Farming
CSL	Central Science Laboratories
CSFO	Catchment Sensitive Farming Officer
Defra	Department for Environment, Food and Rural Affairs
DETR	Department for Transport, Environment and the Regions
EA	Environment Agency
EC	European Commission
ECSFDI	England Catchment Sensitive Farming Delivery Initiative
EIA	Environmental Impact Assessment
ES	Environmental Stewardship

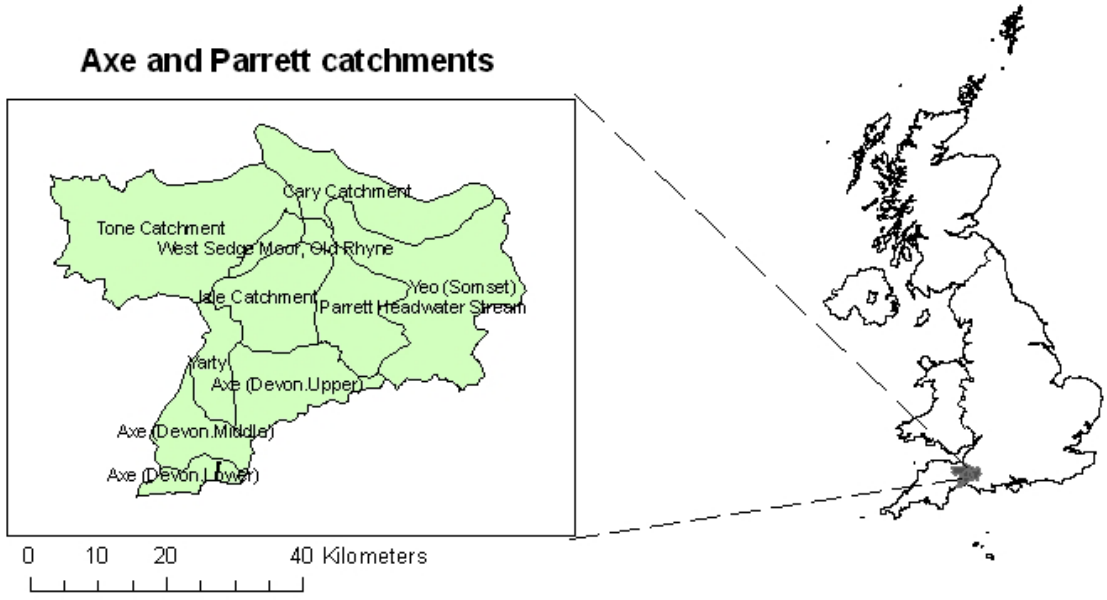
EU	European Union
FWAG	Farming and Wildlife Advisory Group
GAEC	Good Agricultural and Environmental Condition
MAFF	Ministry of Agriculture, Fisheries and Food
MS	Member State
NE	Natural England
NFU	National Farmers' Union
NGO	Non-governmental Organisation
NVZ	Nitrate Vulnerable Zone
Q	Questionnaire (e.g. Q2 is the Questionnaire for Farmer Interviews) Letter and number refer to the Part of the question-nnaire and the question (e.g. B4 is the question 4 in Part B)
QUANGO	Quasi-autonomous non-government organisation
RDP	Rural Development Programme
RPA	Rural Payments Agency
RSPB	Royal Society for the Protection of Birds
SMP	Soil Management Plan
SPR	Soil Protection Review
SPS	Single Payment Scheme
SSSI	Site of Special Scientific Interest
SWRDA	South West Rural Development Agency
WCRT	West Country Rivers Trust
WFD	Water Framework Directive

1 Introduction to the case study area

Although the UK is generally not associated with high rates of soil erosion, there are a number of locations throughout the country where the combination of rainfall, soil type, slope properties and land use and management can result in unacceptable losses of soil and associated nutrients and agrochemicals, which can have adverse impacts on receiving waters. The spatial distribution of such areas has been mapped at the national scale (Morgan, 1985; Boardman and Evans, 2006), and they include the Axe and Parrett catchments in south west England. These catchments are well known for their problems of soil erosion, soil compaction and diffuse pollution, all of which are associated with agricultural activities. These conditions (and possible solutions to these problems) are representative of other areas in the UK where soil erosion and soil compaction are major threats to soil resources. Both catchments are assigned as priority catchments in the Catchment Sensitive Farming scheme[6]. Local initiatives such as the Parrett Catchment Project [7] have sought to mitigate soil erosion problems, from which lessons can be learned for effective policy in the future.

The Axe and Parrett catchments are located in south west England (Figure 1), and their sizes are 290 km^2 and 1690 km^2 respectively. The Parrett catchment consists of the sub-catchments of the rivers Isle, Parrett, Tone and Yeo.

Figure 1: Location of Axe and Parrett catchments



The rivers in the catchments are characterised by a flashy response to rainfall with rapid runoff and accompanying soil erosion problems typical of low permeability catchments.

The elevation ranges from 10 m to 400 m altitude. Average annual rainfall (measured over the period 1971 – 2000) in the region is 724.5 mm, average maximum temperature is 14.4º C and average minimum temperature is 6.0°C (Metoffice, 2008). Table 1 gives the monthly averages.

6 http://www.defra.gov.uk/farm/environment /water/csf/index.htm

7 http://www.parrettcatchment.info/

Table 1: Climate averages: Yeovilton, 1971-2000

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Rainfall (mm)	72.0	55.6	56.6	47.3	48.9	57.2	48.9	56.6	64.5	67.9	65.8	83.3	724.5
Max temp (°C)	8.1	8.3	10.6	12.9	16.5	19.3	21.7	21.5	18.6	14.8	11.1	9.0	14.4
Min temp (°C)	1.4	1.3	2.7	3.7	6.8	9.7	11.9	11.7	9.6	6.9	3.6	2.4	6.0

Source: Metoffice, 2008

The main farming systems in the Axe and Parrett catchments are grazing livestock (beef and sheep) and intensive dairy. The farmland in the Axe catchment is intensively used to the limit of the watershed, with few areas of woodland or extensive pasture (Defra, 2007b; Smith, 2007). The intensification of dairy production has been associated with a considerable increase in the cultivation of maize over the past 15 years, but also the area of oilseed rape and winter wheat has increased.

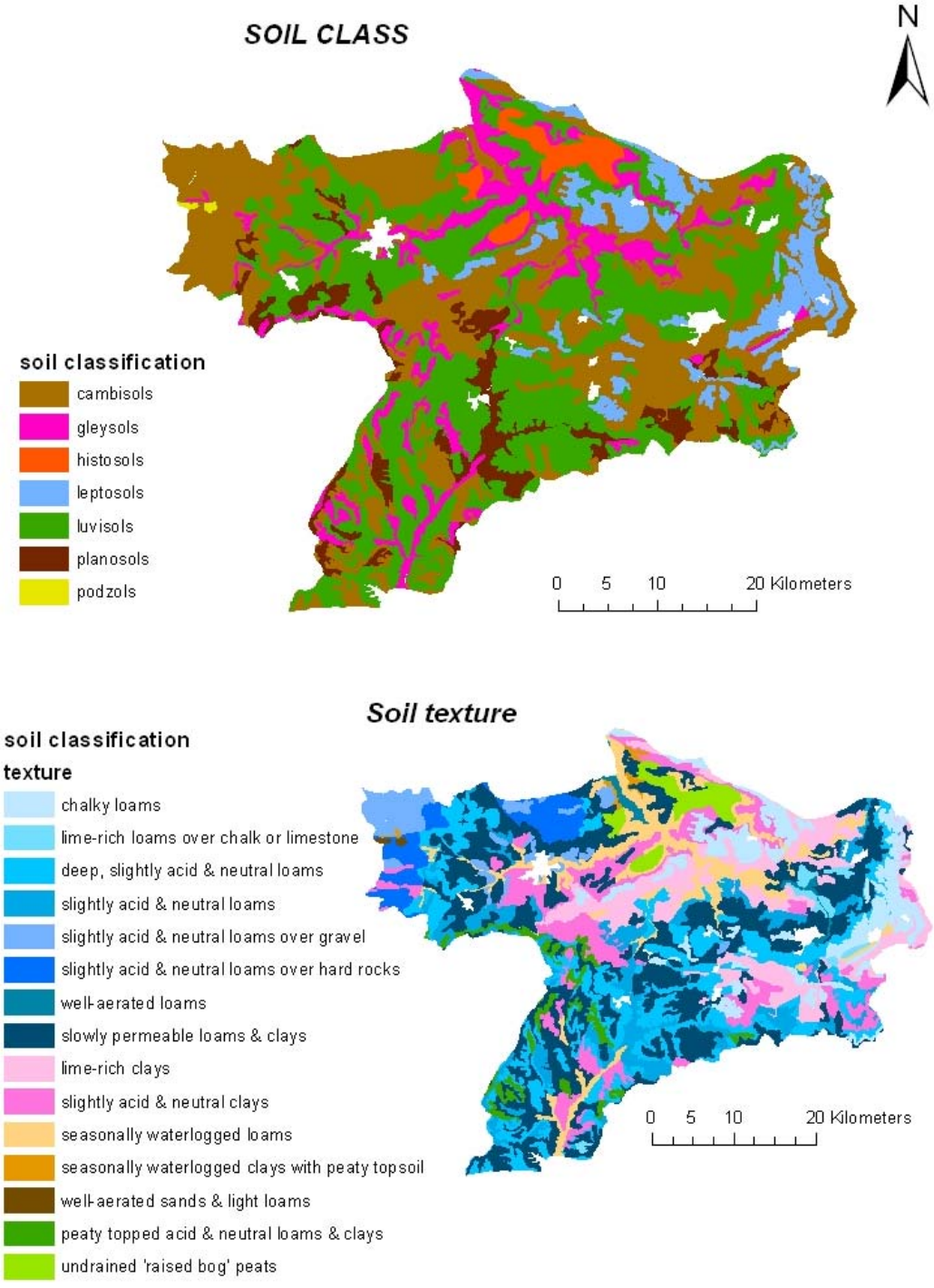
The soils in the Axe and Parrett catchments are prone to soil compaction and soil erosion, resulting in soil degradation, diffuse pollution and muddy floods. Changes in agricultural land use (such as intensification and increases in cultivation of erosion-inducing crops) and soil management practices have exacerbated these problems over the last two decades.

Figure 2 shows the classification of soil classes and textures in the Axe and Parrett catchments. Cambisols and Luvisols are the predominant soils, with Gleysols in the valleys, but Leptosols and Histosols (Parrett) and Planosols (Axe) are also common. Cambisols form particularly good agricultural land and are intensively used for farming. Luvisols are also fertile soils, and with a good drainage status they are suitable for a wide range of agricultural uses. However, structural degradation can easily occur if these soils are tilled under wet conditions. Leptosols are young, shallow soils and they are very prone to erosion. Planosols have poor physical and chemical soil conditions and are subject to waterlogging during wet periods. Gleysols are almost permanently waterlogged and typically used for pasture. However, when drained, these soils can also be used for arable cropping (Driessen and Dudal, 1991). The majority of the soils in the case study area are loamy soils that are susceptible to erosion. The Parrett catchment also has large areas with clay soils. Without drainage, the soils in the valley bottoms are typically waterlogged during winter, but many of these are currently intensively drained.

A mixture of policy measures is in place to address these problems. In particular these include cross-compliance, voluntary agri-environment schemes and the Catchment Sensitive Farming scheme.

No large-scale quantitative studies currently exist on the effectiveness of soil conservation policies in the area.

Figure 2: Soil maps for the Upper Axe and Parrett catchments



Source: own presentation by NSRI, Cranfield University (www.cranfield.ac.uk/sas/nsri/)

2 Methodology

The aim of this report is to provide an account of the soil degradation processes, soil conservation measures, soil-related actors and policies in the case study area set in a national context. It is based on a two stage literature review and document analysis, and a set of semi-structured interviews with the complete range of identified soil-related actors in the case study area and national organisations.

Two kinds of interview survey were selected and followed. The first were interviews with soil and farming experts or their colleagues, conducted by project partners from ZALF. They were aimed at giving a general picture of soil degradation processes and suitable farming practices in the area.

The second set of interviews was directed at stakeholders in the case study area who are or should be directly or indirectly involved in soil conservation efforts or policy. The interviewees can be classified as falling within one of the following three action situations:

(1) Farming practices;

(2) Policy implementation;

(3) Policy design.

The interviews were aimed at ascertaining these stakeholders' perceptions and preferences regarding soil conservation in the case study area, to be used as one data base for the empirical analysis of institutional choice, institutional performance, and institutional change. Partners from Cranfield University interviewed six farmers and three farm advisors in the case study area on farming practices and soil conservation issues (see Annex). Partners from IEEP interviewed 11 administrative and governmental actors, and 9 actors operating outside public bureaucracies. In total, 29 interviews were conducted. Interviews were designed so that the stakeholders assessed the soil management and degradation processes in the case study area, the institutional structures encountered within the case study area, and their performance.

The interviews were semi-structured, with the majority conducted face-to-face, supported by additional telephone interviews. With the informed consent of the interviewee a digital recorder was used for recording the interview and, in its absence, notes were taken. The interviews were made using questionnaires tailored for the specific stakeholder, designed with a modular structure allowing them to be adjusted to the respective interviewee to obtain maximum insight into the relevant areas of their knowledge or expertise. A full list of interviewees can be seen in the table in the Annex. Upon completion, interviews were written up so that answers could be used to inform the conclusions of this report.

3 Perception of soil degradation in the case study area

3.1 Soil degradation processes

From interviews in the case study catchments and from expert opinion, five degradation processes have been identified in the Axe and Parrett catchments in south west England; namely, soil compaction, soil erosion, diffuse contamination, reduction in water retention capacity and decline in organic matter. The definitions, causes and impact of these specific soil degradation processes within the study catchments are listed in Table 2. Of these, soil compaction and soil erosion are considered to be the main soil degradation processes in the region.

Table 2: Experts' opinions on soil degradation processes in the UK case study catchments

Soil degradation process	Causes	Impact
Soil erosion by water (*loss of top soil*): The detachment and transport of soil particles in a field and potentially beyond the field boundary.	• Surface runoff • Soil extraction with root crops • Construction • Bare soil at inappropriate times • Slope length and gradient • Cultivation techniques • Concentrated flow	• Damage to crops • Reduced soil fertility • Loss of resource • Hazard e.g. mud on roads • Sedimentation in watercourses • Reduction in channel capacities • Flooding risk
Decline in organic matter: Organic matter aids water retention, provides substrate for soil biota, improves soil structural stability and enhances nutrient retention and recycling.	• Oxidation • Repeated disturbance to the soil • Extended grazing season • Intensive arable farming • Inorganic fertiliser • Soil erosion (see above)	• Structural degradation • Soil sealing/crusting • Reduced infiltration • Increased vulnerability to compaction and soil erosion.
Diffuse contamination: Pollution (e.g. by agrochemicals and sediment) arising from a non-specific point.	• Over application of nutrients • Perception of farmyard manure as a waste product • Inappropriate timing of agrochemical and slurry applications • Bare soil at vulnerable times leading to soil erosion • Soil compaction or capping reducing infiltration and leading to generation of potentially erosive overland flow • Proximity of farming activities to watercourses • Connectivity to a watercourse • Intensive rainfall	• Eutrophication of water system • Damage to aquatic habitat • Siltation of navigable channels • Health issues • Water quality • Loss of nutrients / agrochemicals on-site

Compaction: A physical reduction in soil porosity resulting in a loss of volume and restriction of water, air and root development. A soil's ability to support a load depends on its water content and structural stability.	• Working the land when wet • Extending grazing into the wet season • Intensity of land use (e.g. stocking rates) • Number of times land is driven over or walked on, or 'trafficked' • Focused animal movement e.g. feeders and water troughs	• Reduces infiltration • Reduces water retention capacity of land • Increases generation of surface runoff • Increases flooding risk • Increases risk of further compaction • Reduces crop yield/quality because of poor root development and less water available to the crop
Reduction in water retention capacity: Soil water retention is the ability of soil to store water in pore space and is dependent on pore size distribution, pore connectivity, soil texture and organic matter content.	• Loss of organic matter • Compaction of soil structure • Exposure of sub-soil through soil erosion of surface soil layers.	• Lower crop yields • Increased runoff • Increased risk of flooding • Increased dependence on irrigation (especially in the light of climate change)

Source: Case study interviews

The most severe soil compaction problems in the study catchments are broadly linked to late harvested crops such as maize and winter cereals and high stocking rates, primarily but not exclusively on heavier clay rich soils. These soils are particularly vulnerable to compaction when wet, therefore working the land in autumn, classified as a wet season, increases the potential for compaction. The consequences of soil compaction are a loss of productivity because restricted root development and less water availability to the crop leads to a reduced crop yield. This not only has economic consequences but can also lead to higher erosion risk because of poor surface protection by the vegetation cover. Soil compaction also reduces soil water retention capacity because it reduces porosity, which increases the potential for generation of surface runoff (and associated diffuse pollution from sediment, agrochemicals – pesticides and nutrients, pathogens and heavy metals).

The lighter loamy soils (see Figure 2) are more vulnerable to soil erosion, especially under intensive agriculture, when little organic matter is returned to the soil, and in preparing a fine seed bed, two cultivations are often carried out to break down soil aggregates into a crumby structure (NSRI, 2001).

These practices have reduced the structural stability of these soils so that they are vulnerable to surface slumping and capping. While the soil below the surface remains freely draining, the reduced infiltration capacity at the surface prevents infiltration and promotes generation of surface runoff. The complex topography of the landscape, planting crops in rows (in particular running up/down slope) and the use of tramlines and other wheelings[8],

8 Wheelings are impressions left in the soil surface after a vehicle, such as a tractor, has passed over.

leads to convergence of surface runoff that is of sufficient erosive force to cause rill[9] and, under extreme conditions, gully[10] formation in the landscape.

When questioned about the symptoms of soil degradation in the area, all farmers and farm advisors were aware of soil compaction causing lower infiltration rates; 5 out of 6 farmers and all farm advisors were aware of runoff from fields discharging onto roads, the presence of water erosion features (e.g. rills), and the loss of top soil; 4 out of 6 farmers and all farm advisors were aware of slumping caused by unstable soil and crusting/sealing. No farmers or farm advisors were aware of any wind erosion, salinisation or salt crust problems within the catchments. The burrowing activities of wildlife such as badgers and rabbits were also highlighted, by farmers and farm advisors, as a problem in the area causing considerable damage to soil. Of particular concern was the tendency of animals to burrow between fields providing a pathway along which sediment and solute could transfer from one field to the next.

Both farmers and farm advisors associated the following crops or management systems with degradation processes: maize, potatoes, continuous cereals, late harvest and autumn grown cereals, root crops and extended grazing seasons.

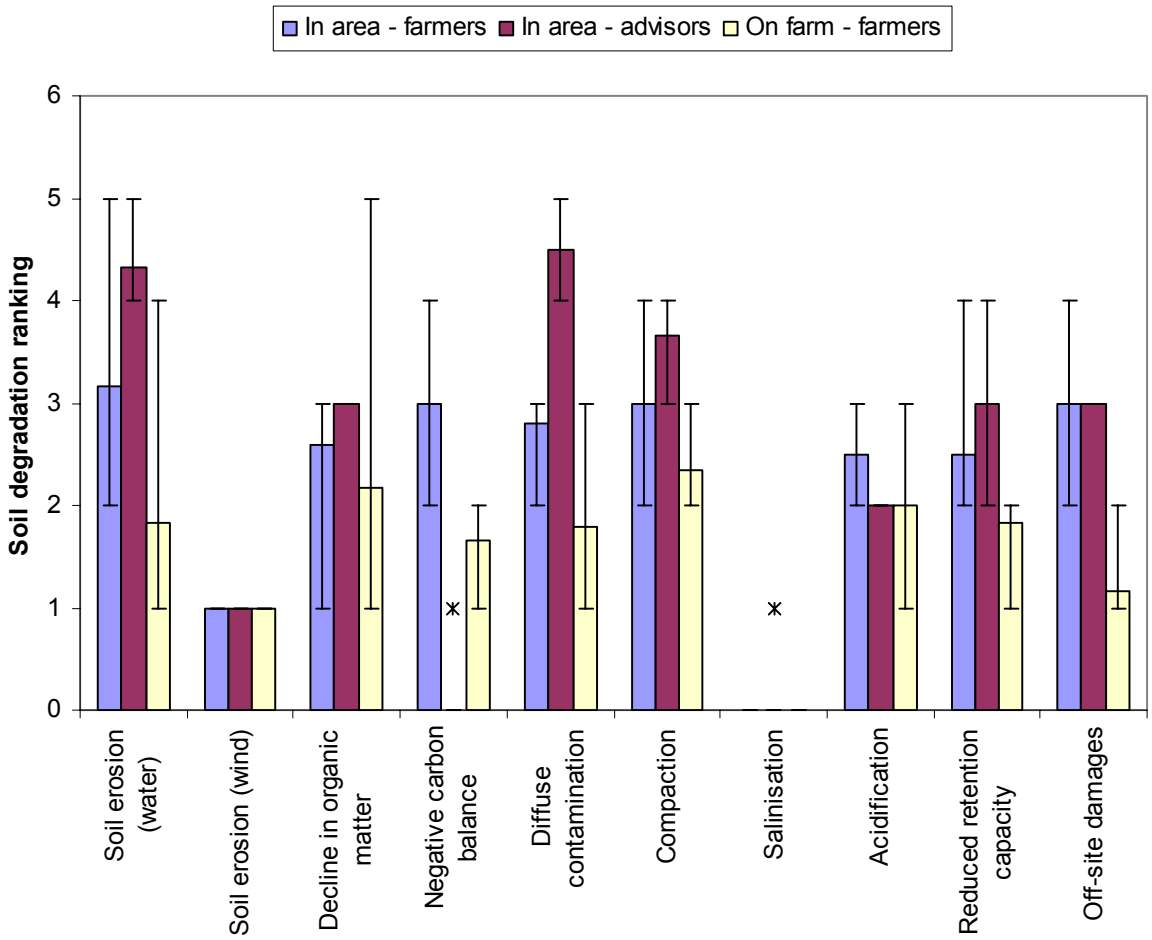
The perceptions of farmers and farm advisors regarding the severity of soil degradation processes in their area are compared in Figure 3. Farmers perceived a slightly lower risk of soil degradation processes than farm advisors, with the exception of acidification. It should be noted that the farmers' perceptions of acidification were linked to the need for lime to be applied to fields to release nutrients, primarily in the Parrett catchment. The largest differences of opinion between farmers and farm advisors related to the responses regarding soil erosion by water, diffuse contamination and negative carbon balance (Figure 3). Farm advisors all declined to give an opinion on negative carbon balance because of the lack of available data. Farmers based their assessment of negative carbon balance mainly on the amount of fuel and inorganic fertiliser used in crop production. The perception is that intensification has led, in particular, to an increased use of fuel and inorganic fertiliser. However, none of the farmers were certain as to how much extra carbon sequestration was achieved (if any) through associated increases in yield. The three soil degradation processes that ranked >3 for farmers and farm advisors were soil erosion by water (3.8), diffuse contamination (3.7) and compaction (3.3).

Figure 3 also compares the farmers' perception regarding soil degradation processes on their farms and in the wider area. With the exception of soil erosion by wind and acidification, on average all other problems were considered to be less of an issue on their farms than in the wider area. This was because the farmers had changed their land management practices in order to reduce soil degradation as recommended by farm advisors. Also, in this particular sample 3 out of 6 farms were being run organically, a much higher proportion than in the area as a whole. Soil degradation can, and often does occur under organic management, but the view of local farm advisors was that the extensive nature of organic farming reduces the pressure on the land and the use of organic fertilisers returns organic matter to the soil increasing the soil resilience, particularly on pasture. The maximum ranking of 4 for soil erosion by water and 5 for decline in organic matter on one farm, were associated with soil degradation under a conventional system growing high quality potatoes. The farmer was aware of the damage to the soil caused by this crop, but, felt that the premium price paid for quality potatoes outweighed any soil degradation that might occur.

9 Rills are narrow and shallow channels in the soil caused when the erosive force of overland flow exceeds the resistance of the soil to that force. A rill can be ploughed out or removed by subsequent rainfall events.

10 Gullies are formed by erosion of soil by overland flow, and often evolve from rills. They are much deeper and wider than rills and by definition cannot be ploughed out. They are associated with very high rates of sediment movement.

Figure 3: **The mean perception of severity of soil degradation processes in the Axe and Parrett catchments**



Ranked from 1 = no problem through to 5 = severe problem, in the area (farmers and advisors, 9 respondents) and on the farm (farmers only, 6 respondents). Bars show range in response and * indicates where no response was given.

Source: Case study interviews

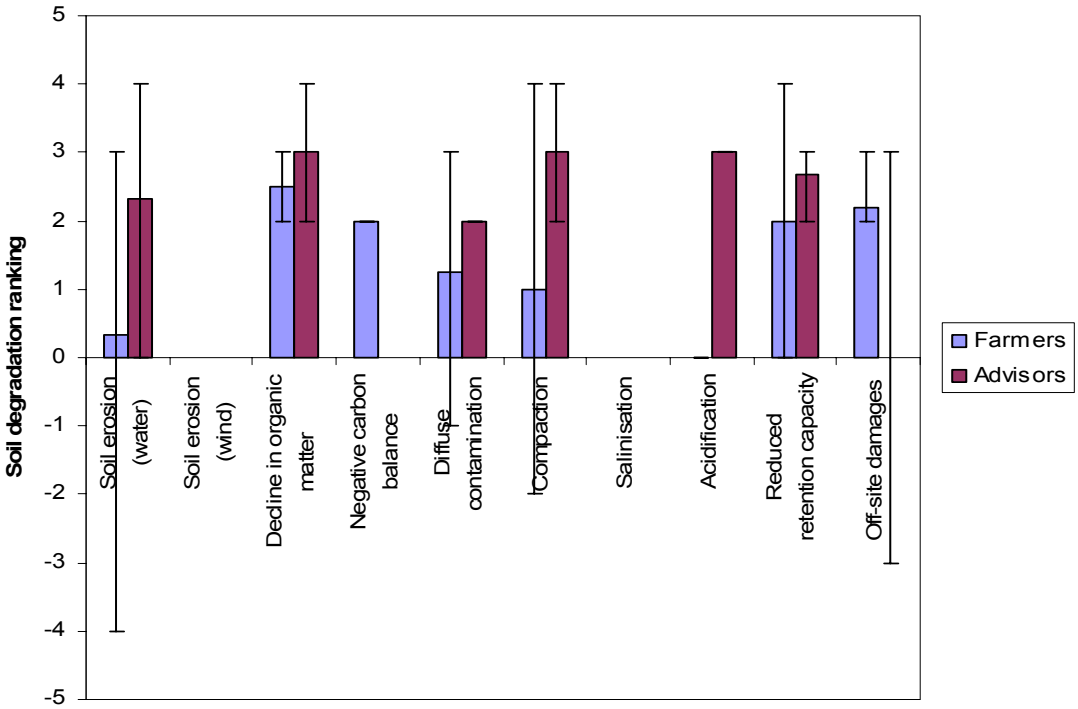
3.2 Trends in soil degradation and consequences

The perceived trends in soil degradation over the last 10 years in the catchment are presented in Figure 4. The general perception is that soil degradation processes have shown a slight to moderate increase over the last 10 years. However, as can be seen from Figure 4, opinions sometimes varied widely.

On average farmers perceived a smaller increase in soil degradation due to soil erosion by water, decline in organic matter, diffuse contamination, compaction and reduced water retention capacity, than farm advisors. However, the farmers' opinions on changes in the degree of soil erosion by water varied widely from -4 to +3. Those farmers that perceived a reduction in soil erosion by water suggested this was because of a better understanding of soil compaction (how to prevent it and how to amend it) leading to a reduction in runoff rates, while farmers who perceived an increase in soil erosion by water suggested agricultural intensification and climate change were the main reasons for this. The later point has been suggested before by Beven et al. (2008) for other UK catchment areas. Advisors suggested that soil erosion by water had been increasing due to intensive farming practices but advice,

in particular relating to remediation of soil compaction, in recent years had led to a reduction in surface runoff (where such advice had been taken up). However, changing weather patterns had led to an increase in surface runoff generation in summer months. For farmers, the primary impact of surface runoff is yield reduction due to nutrient loss and crop damage.

Figure 4: **Trends in the mean perception of soil degradation in the Axe and Parrett catchments over a 10 year period**



Data ranked 1 for small changes to 5 for large changes. Positive values indicate an increase in soil degradation and negative figures indicate a decrease in soil degradation. The range of values is indicated by bars. Data based on 6 farmers and 3 farm advisors.

Source: Case study interviews

Both farmers and farm advisors agreed that there had been a general decrease in organic matter in the soil. Some farm advisors were reluctant to suggest by how much, because there was no supportive data. However, evidence of declining organic matter content in UK agricultural soils has been presented by Bellamy et al. (2005). Organic farmers believed (although no supporting evidence was given) that since they had changed from conventional to organic farming, levels of organic matter in the soil had increased because they utilised their available farmyard manure supplies. However, it was noted that the traditional plough used to bury weeds and prepare the ground will oxidise a proportion of this organic carbon when applied as manure. As fertiliser costs increase, the perceived trend will be for conventional farmers to also make better use of their farmyard manure (if available) and it was anticipated by some that this may halt or even reverse the decline in organic matter, especially when combined with minimum tillage.

There was a general belief among the interviewees that over the past 10 years there has been a slight to moderate increase in diffuse contamination in the aquatic system linked to compaction and increased surface runoff. However, recently (in the last 2 to 3 years) this trend has begun to reverse, due to better advice on fertiliser use and soil testing for example, and incentives through payments to reduce runoff (e.g. through participation in the voluntary

agri-environment scheme [Environmental Stewardship]). Farm advisors generally believe that farmers, whilst being aware of runoff occurring on their land, were less aware of the significance that the runoff may have in the wider environment. This impression of a lack of awareness of a wider environmental responsibility by farmers was also supported by an account given in Ingram (2008) that covered opinions of a greater number of farm advisors in the UK. The threat of prosecution by the Environment Agency (under the Water Resources Act 1991 and Highways Act 1980) has made some farmers modify their practices to prevent further pollution. The other driver for change is the economic benefit of reducing the costs associated with nutrient losses.

While both farmers and farm advisors generally agreed that there had been an increase in soil compaction, on conventional farms, over the past 10 years, farmers consider this increase to be less marked than farm advisors. Both agreed that the increase in compaction was due to a general intensification of farming practice, use of contractors, increase in land under certain crops such as maize and potatoes, and a tendency to extend the grazing season into autumn. It is believed that this trend is also reversing now that farmers have been given more advice on appropriate soil compaction remediation and prevention measures. The farmer who perceived a decreasing trend (-2) in soil compaction on his farm, said this was a result of a change in maize variety, allowing an earlier harvest and subsequent earlier planting of winter wheat.

The decline in water retention capacity was perceived to have followed a similar trend to soil compaction. By taking remedial action to deal with soil compaction, the soil's water retention capacity will also be improved. There was general awareness that water retention capacity is linked to organic matter content but a lack of data on soil organic matter made it difficult to assess the effectiveness of increasing organic matter content in the area. Only one advisor in the Parrett catchment put forward the idea that reduced water retention capacity could potentially lead to flooding in the catchment.

The farmers thought that carbon emissions had slightly increased due to an increase in fuel consumption and inorganic fertiliser input. However, neither farmers nor farm advisors were able to suggest how agricultural production and soil management affected the negative carbon balance. The main reason given for this was lack of available data.

Acidification was not perceived to be an issue in the Axe catchment, with only one advisor in the catchment perceiving a moderate increase in acidification. In the Parrett catchment although acidification was not perceived to be a problem, there was a tradition of adjusting soil pH levels by using lime in order to optimise crop production through more efficient nutrient uptake.

Farmers perceived a moderate increase in offsite damage primarily due to increasing size of (farm and domestic) vehicles causing damage to roadside verges. Their perception was that mud on the road was more critical than loss of soil from the field. The farmers were less aware of damage that may be caused by agro chemicals and sediment entering watercourses. Farm advisors were of the opinion that while offsite damages had been increasing, advice on preventative and remediation measures e.g. buffer strips, subsoiling, cover crops, etc., given in recent years had started to reverse the trend.

The opinions of farmers and farm advisors generally matched those of the expert opinions on soil degradation trends in the case study catchments. While there has been a trend over the past two decades of increasing soil degradation (mainly due to intensification of farming practices and market driven production), over the last 2 to 3 years this trend has begun to reverse, as better land management advice has been made available (Pers. Com., CSFOs, FWAG). Nevertheless, the importance of profit still outweighs soil conservation in the decision-making of some farmers, as one farmer explained they were still prepared to grow potatoes, a crop with high net margins but also with high risks of soil erosion, on land prone to soil degradation. However, soil conservation has improved in areas where farmers have interacted with farm advisors. Issues still remain with engaging a small proportion of farmers

that cause a proportionately high percentage of diffuse contamination in the catchments. Also, according to one farm advisor, 10 % of problems are caused by unforeseen circumstances i.e. things that cannot be managed (e.g. weather). Although historically the autumn was defined as the wet (and thus high degradation) risk season, the apparent climatic change to more intensive rainfall events during the 'dryer' summer months may require a further change in farm practices to manage the land more appropriately throughout the year if soil degradation is to be avoided.

4 Farming practices and soil conservation measures

The main farming systems in the Axe and Parrett catchments are grazing livestock (beef and sheep) and intensive dairy (Table 3). Arable crops in the catchment are a mixture of fodder crops (e.g. maize and peas), cash crops (e.g. wheat, potatoes and carrots) and energy crops (e.g. miscanthus).

Table 3: Percentage of farm types in Axe and Parrett catchments, 2005

	Cereals	General cropping	Horticulture	Pigs & poultry	Dairy	Grazing livestock	Mixed	Other*
Axe	3	0	4	2	18	24	4	44
Parrett	5	2	6	4	10	25	5	56

*includes land used for horses or limited economic importance

Source: Defra, 2007a

The Axe catchment (Figure 5) is intensively used with few areas of woodland or extensive pasture (Defra, 2007b; Smith, 2007). The intensification of dairy led to a considerable increase in the cultivation of maize as a fodder crop over the past 15 years. In the Parrett catchment (Figure 6), the cultivation of maize increased in the early 1990s but has not seen an increase since as observed in the Axe catchment. Oilseed rape is grown widely but winter wheat remains the most important crop in both catchments.

Figure 5: Historical changes of main crops in the Axe catchment (Defra, 2007a)

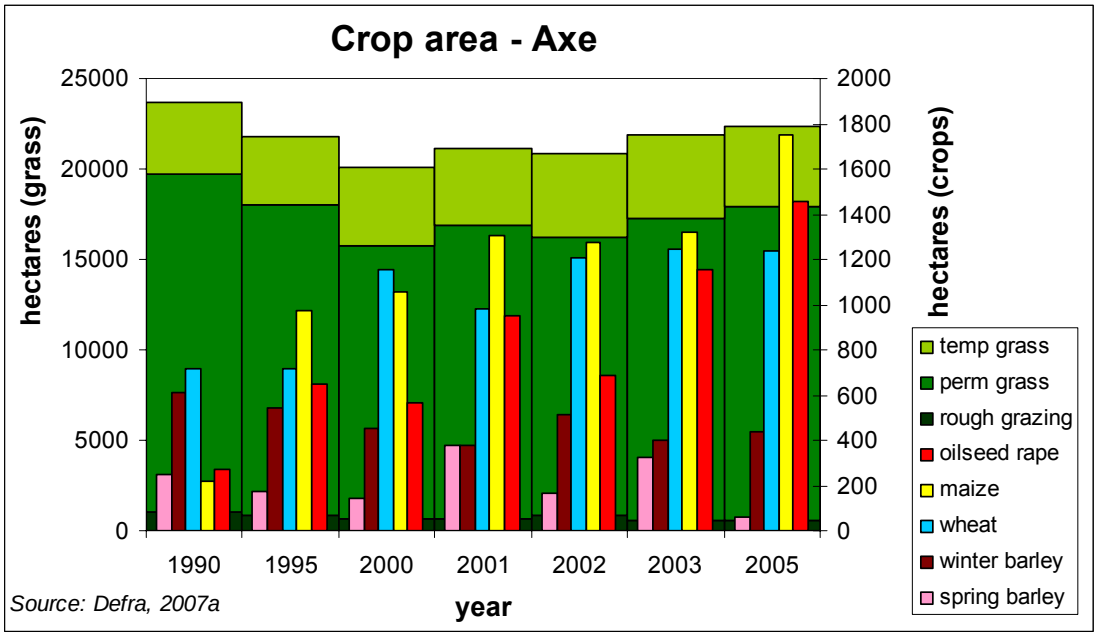
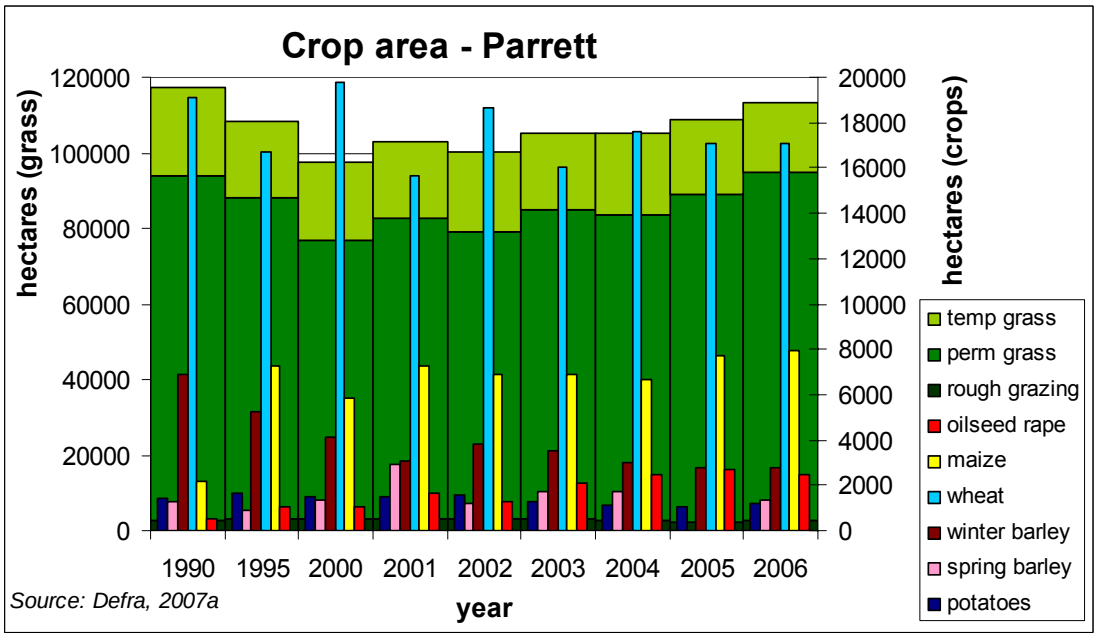


Figure 6: Historical change of main crops in the Parrett catchment (Defra, 2007a)



Conventional farming is by far the most dominant farming system within the study catchments. Commercially viable conventional farms have intensified their activities, i.e. increased the number of livestock units on their land and increased arable yields, in order to remain financially viable. In contrast to this, organic farming, which is typically pasture or mixed in the case study catchments, represents about 3 % of total farmland and is typically an extensive grazing farming system that is financially viable because of the premium prices paid for organic produce (Younie, 2001). The South West has the highest density (29 %) of organic livestock production in the UK. Eighty-five percent of organically managed land in the UK is under permanent or temporary pasture. According to Younie (2001), on a per hectare basis organic farming will support a stocking rate and livestock output equivalent to a

conventional system receiving 180-200 kgN/ha/annum. However, intensive farming which uses greater than 200kgN/ha/annum will support substantially higher stocking rates.

The majority of the registered farms in the Axe and Parrett catchments are smallholdings which are non-viable units. The bigger commercial farms (>50 ha) are typically family farms (Table 4). Three quarters of the farmed land is owner occupied, a quarter of the farmland is farmed by tenant farmers or rented by farmers in addition to their own land (Defra, 2007a). The majority of the working force in agriculture is part-time (Table 5). Most casual workers in the Parrett catchment undertake seasonal work on horticultural farms.

Table 4: Farm numbers according to size, 2005

Farm size	**<5**	**5 <20**	**20 < 50**	**50 <100**	**≥100**
Parrett	2788	1089	729	553	474
Axe	465	197	133	131	75

Source: Defra, 2007a

Table 5: Working force in Axe and Parrett catchments, 2005

	Farmers, full-time	Farmers, part-time	Managers	Workers, full-time	Workers, part-time	Casual workers
Axe	498	580	27	115	120	37
Parrett	2378	3444	95	797	626	1149

Source: Defra, 2007a

Table 6: **Typical cropping systems, their characteristics and the estimation of impacts of soil degradation processes in the case study Axe and Parrett catchments**

Crop	Maize, Fodder - Silage	Grass, temporary (less than 4 years) - Silage	Grass, permanent pasture - Fresh	Cereal, other - Fodder	Soft wheat, winter - Grain	Oilseed, other - Grain	Carrot - Root	Pea - Grain	Beet and Turnip - Fodder	Barley, winter - Fodder	Potato - Root	Pea - Fodder	Strawberry - Fruit	Triticale - Fodder	Miscanthus (for biomass)
Production orientation	Conventional	Conventional	Conventional	Conventional	Conventional	Conventional	Conventional	Conventional	Conventional	Conventional	Conventional	Conventional	Conventional	Conventional	Conventional
Farm type	livestock farm > 1,5 LU	livestock farm > 1,5 LU	livestock farm > 1,5 LU	arable farm	arable farm		arable farm	arable farm			arable farm		arable farm		
Tillage type	Ploughing			Ploughing	Ploughing	Reduced tillage	Ploughing	Ploughing	Ploughing	Ploughing	Ploughing		Ploughing		
Irrigation type	no irrigation	no irrigation	no irrigation	no irrigation	no irrigation	no irrigation	no irrigation	no irrigation	no irrigation	no irrigation	sprinkler - pivot	no irrigation	drip irrigation	no irrigation	
other management options	Undersowing with grass			reduced tillage (leaving rougher seedbeds than conventional tillage)	reduced tillage (leaving rougher seedbeds than conventional tillage)	reduced tillage (leaving rougher seedbeds than conventional tillage)	intercropping with grass	reduced tillage (leaving rougher seedbeds than conventional tillage)		reduced tillage (leaving rougher seedbeds than conventional tillage)	ridge and furrow	reduced tillage (leaving rougher seedbeds than conventional tillage)		reduced tillage (leaving rougher seedbeds than conventional tillage)	
Soil quality class[a]	2	2	1	2	2	2	3	3	2	2	3	2	3	2	

Soil degradation process															
soil erosion water	high vulnera-bility	low	low	high	high	medium	high	medium	high	high	high	medium	medium	high	low
soil erosion wind	low	low	low	low	low	low	low	low	low	low	low	low	low	low	low
decline in organic matter	low	low	low	medium	medium	medium	high	low	high	medium	high	low	low	medium	low
diffuse contamination	high	medium	low	medium	medium	medium	medium	low	high	medium	high	low	low	medium	low
Com-paction	high	high	high	medium	medium	medium	low	medium	medium	medium	medium	medium		medium	low
Decrease of water-reten-tion capacity	low	medium	medium	medium	medium	medium	high	low	high	medium	high	low	low	medium	low
off-site damages	high	low	low	high	high	medium	high	medium	high	high	high	medium	low	high	low

Note: There are three soil quality classes in the case study: class 1 means heavy clay soils (poor quality, poor drainage); class 2 means loamy/clay soils (moderate quality, moderate drainage) and class 3 means loamy/sandy soils on lowlands (good quality, good drainage)
In addition to these results further comments on typical cropping systems were given in the framework of questionnaire 2
Source: ZALF

4.1 Farming practices and their effects on soil

4.1.1 Farming practices that cause soil degradation

The primary causes of soil degradation in the case study catchments are intensive land management practices e.g. high inputs and outputs leading to a build up of pollutants, repeatedly working the land with poor return of organic material, and working the land when wet. Intensification has led to a reliance on inorganic fertilisers and pesticides to maintain productivity. However, these practices fail to return organic material to the soil and subsequently structural stability deteriorates along with soil water retention capacity. Intensive farming practices that include primary and secondary cultivation of the soil to prepare fine seed beds also lead to further mineralisation of organic mater. The finely prepared seed beds, used for potato and other root crop production, provide a source of fine soil particles and aggregates that can be easily detached and transported by rain splash and overland flow / surface runoff. On lighter, sandy soils, fine seed bed preparation combined with poor structural stability can lead to slumping and capping with reduced infiltration capacity at the soil surface which promotes surface runoff. The main erosion features (rills and gullies) found in the case study catchments occur on the lighter soils.

Intensification of arable farming and increasing labour costs have led to an increase in the size of farm machinery used. For example, the average power of a tractor sold in the early 1990s was 70 kW, compared to an average of 95 kW for the tractors sold in the last few years (AEA, 2007). Larger machinery is associated with heavier equipment and an increasing risk of soil compaction (Ansorge and Godwin, 2007), especially when soils are wet (AEA, 2007). However, the relationship between bigger machines and a higher risk of soil compaction is not straightforward. Firstly, bigger farm machinery tends to have bigger tyres, allowing the increased weight to be spread across a larger surface area such that ground pressures have probably not changed proportionately. Secondly, the increased width of the machines reduces the amount of travel in the fields. Thirdly, increased working speeds, facilitated by greater operator comfort, can enable work to be carried out at the optimum time, avoiding potential soil damage due to untimely operations (Beven et al., 2008). The opinion of farm advisors is that while using larger tyre sizes or lower pressures is now widely adopted in the area, this has not been extended to trailers and these remain a potential problem for soil compaction.

The increase in machinery size has been accompanied by an increase in field size and the removal of boundary features such as hedgerows as well as in-field features such as ponds. This is in order to increase the ‘field efficiency’ of farm machinery, improve work rates and reduce average machinery costs per ha (Beven et al., 2008). In Somerset, average field size has changed from 5.5 ha in 1945 to 9.5 ha in 1995 (Harris et al., 2004)

Intensive grazing increases loadings on the soil, which can lead to compaction near the soil surface (known as “cow pans”), especially in areas where animal movement is concentrated, e.g. around feeding and drinking troughs, in gateways and along paths (Heathwaite et al., 1990; Cuttle et al., 2006). Compaction can also occur in fields where grass is cut for silage because of the number of times the silage field has to be trafficked. According to Frost (1984) the entire area of a silage field can be driven over up to nine times each year. In recent years, as animal feed prices have risen, farmers have utilised the late autumn flush of grass to extend the grazing season, made possible by the mild temperatures of the region and elsewhere in the UK (Defra, 2002). However, this extended grazing season lasts into a wetter climatic period. The wet soils are more vulnerable to soil deformation and compaction.

While it is possible to plan to avoid working the land during the wet season it is less easy to avoid unforeseen wet periods. According to local farmers, in 2007 the worst time for soil poaching occurred during July which was unseasonably wet. The increased use of contractors used to work the land also reduces the flexibility of the timing of field operations.

Contractors, because of their commitments and unfamiliarity with the land, may work the land irrespective of the antecedent soil moisture content or predicted weather forecast. Working the land when wet increases the risk of soil compaction and smearing, particularly on heavy, clay rich soils. Ploughing wet soil, as well as repeated ploughing at a similar depth, leads to the development of a compacted plough pan layer just below plough depth. Such plough pans are associated with reduced water movement through the soil, so reducing water retention capacity and increasing the risk of surface runoff generation. Plough pans are also known to restrict root development (and associated yields) in crops.

Certain crop types have been linked with soil degradation within the case study catchments (Table 6), these include maize, potatoes and miscanthus. Maize is regarded as a problem crop because of its early planting and late harvest which often coincide with wet soil conditions and therefore increased risk of soil compaction. The lack of vegetative cover in maize fields during the summer months also makes them susceptible to erosion from summer rainfall events (Boardman et al., 1996), particularly on the lighter soils. Maize is primarily grown as a fodder crop in the case study catchments and because of its ability to take up large quantities of nitrogen, farmyard manure and slurry are often heavily applied.

The preparation of the soil for top quality potatoes that attract a premium price requires a fine, stone free soil environment. Irrigation is frequently used, especially in the early stages when there is little crop cover, to prevent diseases and skin blemishes on the potato crop. Increased use of irrigation on potato crops has allowed lighter soils and steeper slopes to be used to produce potatoes both of which are prone to runoff and erosion (Harris et al., 2004). As with maize, potato crops can leave the soil exposed to intensive summer rainfall events because of the spacing between the potato rows. While ridge and furrow methods are promoted as methods for retaining rain and irrigation water, their inappropriate alignment can lead to convergent flows of water causing soil detachment and transport (erosion).

Miscanthus, which has only recently been introduced to the UK, is grown as an energy crop in the case study catchments and is generally not perceived as an environmental problem crop, because of its low nutrient requirements and good ground cover when harvested for biomass. However, there is some concern that the harvesting of the tubers could result in severe soil damage leading to soil loss through erosion (Defra, 2007c).

Tramlines along which repeated journeys are made, by farm machinery, lead to severe localised compaction. The orientation of these tramlines can have significance: if they are oriented up/down slope, surface runoff can be channelled along the tramline and this can lead to erosion.

4.1.2 Farming practices that prevent soil degradation

Some forms of agricultural extensification can be financially attractive to farmers but only where premium prices can be achieved, e.g. organic production. The land area devoted to organic farming is increasing in the case study catchments. In 2004 97,000 ha was either in conversion or fully organic and in 2007 this had risen to 125,000 ha (Defra, 2007d). The reasons given by farmers for going organic included:

- "*Unable to expand enterprise to achieve economy of scale because of lack of available land. Therefore opted to farm premium priced produce under an organic system."*
- *"Threat of prosecution from Environment Agency over diffuse pollution. A radical change in land management was needed to reduce the risk and felt managing the farm organically would help achieve this in a sustainable manner."*

While there is still a risk of soil degradation under an organic system if poorly managed, the pressures on the soil are less because of the lower stocking densities and higher return of organic matter to the soil associated with organic farming. The organic system makes better use of green manures (e.g. clover, mustard etc.) which will fix nitrogen, provide ground cover at critical times and return organic matter to the soil when ploughed in. Organic farming also makes better use of available farmyard manures and slurries because of the restrictions on the use of inorganic fertilisers imposed on this type of farming. With the increase in fertiliser prices and advice from CSF officers and FWAG, conventional farmers in the area are also beginning to make better use of their available waste resources, which should help to increase organic matter content in the soil.

Farm advisors and soil experts agree that subsoiling[11] and soil aeration are important mechanisms for reducing soil compaction in both arable and grassland field sites in the study catchments. Subsoiling, when used under appropriate conditions, can break up compacted zones at depth in the soil profile, including plough pan layers. However, it is less effective at reducing any shallow surface compaction associated with pasture (Clarke et al., 2008). This is because the soil is often more moist under pasture because of a higher organic matter content near the soil surface which retains moisture; this prevents effective shattering of the surface soil layers. According to farmers and farm advisors, soil aerators that slice and disturb the top few centimetres of soil work better for pastures, although care still needs to be taken to avoid wet conditions. Both subsoiling and aeration have the potential to increase yields, reduce surface runoff and increase soil water retention capacity.

Having drier soils by improving drainage can reduce the risk of soil compaction and extend the productive season of most farming systems. While some new drainage had been installed recently by a few farmers, most of the subsurface drainage was installed before the 1980s. Between 1940 and 1980s (when grant aid was available to install drains) 40 to 60 % of the land in the region was under-drained (Robinson, 1990). Some of these drains still function efficiently.

New varieties of maize are now becoming available to farmers that mature quicker and therefore can be harvested earlier when the soil moisture conditions should be more favourable. This allows a winter cereal to be planted earlier and to become established over the wet winter period offering greater protection to the soil surface over winter. This is a relatively new approach being introduced to the region, and has potential for future application (Pers. Com., CSFO).

While arable crop rotations are normal practice in the catchments, most are considered to be traditional rotations relatively unchanged for more than 10 years. However, some changes have been made, for example to extend the period of time between potato crops to 5 or 6 years to prevent skin blemish diseases. Within the rotations break crops and cover crops are sometimes included e.g. forage rape or mustard grown over winter between wheat and barley, or growing cereals after maize or sowing rye grass after maize. Both conventional and organic systems use crop rotation to prevent the build up of pests and diseases. This is more important under an organic system because of the restrictions on chemical use. However, conventional farmers are finding many agro-chemicals have been restricted and are no longer available to them and/or the price of the chemicals is a consideration. Farm advisors have encouraged conventional farmers to grow a cover crop over winter periods to reduce runoff. The main cover crop in the catchment is grass; however, its effectiveness to protect the soil depends on the age and quality of the sward (Scholefield and Hall, 1985). Young reseeded pasture and overgrazed swards, which both have lower sward densities, can lead to increased risk of compaction and erosion (Clarke et al., 2008).

[11] Subsoiling is a process whereby compaction or unfavourable structure at depths below 30 cm is eliminated by a process of loosening. The process lifts and creates cracks (“shattering”) in a dry soil, so improving soil aeration, infiltration and root development (see NSRI, 2001)

Practices that restrict the area of land that is trafficked offer the potential of reduced compaction over the majority of the land surface, better infiltration capacity and in principle reduction in the amount of runoff generated on the land. Two practices are used in the study catchments. First, in arable systems, larger machines are now generally used, which means fewer tramlines over the area. A second system that is being trialled by a few farmers in the area is restricted animal movement, including the use of temporary paddocks.

Intensification of farming practice has seen a steady increase in the size and weight of vehicles being used. The larger size of the vehicles has reduced the area trafficked on a field and the number of repeat trips being made with trailers carrying harvested crops. To lessen the impact of the increased weight of the vehicles some farmers are using either wider or low pressure tyres which are designed to spread the load over a greater area, reducing the compaction for a given axle weight.

While organic farmers tend to favour conventional tillage that lifts and inverts the soil (Peigné et al, 2007), so burying weeds, conventional farmers have begun to embrace reduced tillage techniques following advice from farm advisors and discussion with other farmers. Advantages of reduced (non-inversion) tillage include reduction in organic matter mineralisation, greater returns of organic material from stubble and reduced fuel consumption because of fewer passes with the vehicle and lower traction resistance. Reduced tillage techniques have been shown to reduce concentrations of sediment and phosphorus in runoff due primarily to better surface cover and a firmer surface that is less susceptible to compaction and sealing (Withers et al., 2007). However, the technique requires a higher use of herbicides to control weeds. This has a negative environmental affect, but if an improved soil structure is achieved then these chemicals will infiltrate the soil rather than being lost in surface runoff. If farmers are confident that chemical losses are reduced in this way, they may be able to reduce application rates too. Other evidence exists that reduced tillage may in the long term also result in a greater loss of nitrate than a conventionally ploughed field (Catt et al., 2000).

Having more localised real time weather forecasting that farmers could rely upon would enable better timed management of the land. This facility could be used to improve the timing of fertiliser application and harvesting, to avoid rainfall events that could lead to loss of nutrients and compaction.

4.2 Suitable soil conservation measures

4.2.1 Cropping/tillage measures

An assessment of the effects of different cropping and tillage soil conservation measures in mitigating soil degradation processes in the case study catchments is shown in Table 7. Practices with the potential to substantially mitigate one or more soil degradation process(es) are suggested for soil erosion by water, decline in organic matter, diffuse contamination, compaction and off-site damage. Each measure that is considered appropriate to the case study catchments is considered in more detail below and can be compared to other measures using Table 7.

Table 7: Effects of cropping/tillage soil conservation measures on soil degradation processes

	Soil degradation process									
Measures	soil erosion water	soil erosion wind	decline in organic matter	negative carbon balance	diffuse contami-nation	compaction	salinisation	acidification	decrease of water reten-tion capacity	Off-site damage
intercrops	2		ne		2	0				2
undersown crops	2		2		2	1				2
grass strips	1		1		1	0				1
reduced tillage	2		0	1		ne				1
contour tillage	1		0	0					1	1
restriction of row crops on steep slopes	2		0			0				2
wheel sizes and pressure / restricting excessive heavy machinery use	1					2				
restrictions on the max. amount of (liquid) manure application					2					1
restrictions on the max. amount of N- fertilisation					2					1
restrictions on the max. amount of P-fertilisation					2					2
controlled livestock movement	1		0		1	2			1	1

Legend: The numbers indicate *the general effects of soil conservation measures on soil threats in the case study*, examined in questionnaire 1 with the following units: 2 = farming practice highly mitigates the threat, 1 = farming practice mitigates the threat, 0 = farming practice has no effect on threat and 'ne' indicating that it is dependent on other variables. The grey marked cells are not relevant because this measure has no relationship to the threat.
Source: ZALF

- Intercropping: Not widely used in the case study catchments, but has the potential to intercept potentially erosive rainfall, reduce overland flow generation through improved infiltration and therefore to reduce soil erosion and nutrient loss. The technique also increases the biodiversity of the field. However, increased competition between the crops can reduce overall crop yields. One solution is to use selective herbicides to kill the intercrops once the main crop has reached sufficient protective surface cover. The negative environmental impact of increased agro-chemical use may counter-balance any benefits in soil protection.
- Undersown crops: Not widely used in the catchment but has potential to maintain surface cover against raindrop impact and overland flow generation, so reducing soil erosion and nutrient loss.
- Grass strips: Has potential to reduce overland flow effectively and erosion in particular on the lighter sandy soils in the catchment. The grass strips can be used in a number of ways including mid-field to reduce slope length, on the down slope edge of the field and in areas of convergent flow, to either prevent soil erosion or to promote deposition of eroded material.
- No tillage/direct drill: not used in the study catchments. This is because initial trials by farmers on heavier clay rich soils showed these techniques led to compaction which resulted in more overland flow than under conventional systems. However, since these initial trials, more has been learnt about how these techniques can be used on different soil types. If soil moisture levels are carefully monitored and the land is worked under optimal conditions, then this method could be used successfully in the area. However, this would require flexibility within the farming system to achieve this to enable the land to be worked under optimal conditions. The heavy reliance on contractors in the farming system may preclude this as contractors have their own schedules that they need to keep to.
- Reduced tillage: This technique is being used more widely in the catchment since being promoted by farm advisors and in farming press. It has the advantage of reducing the rate of organic matter mineralisation and reduces disturbance to the soil structure, both contributing to an overall improved structural stability. This promotes infiltration, reduces surface runoff and increases soil water and nutrient retention capacity. The main disadvantage with reduced tillage is the increased use of herbicides used to control weed populations, and concerns over long-term compaction, requiring techniques such as sub-soiling to break up the untilled layers.
- Contour tillage: is used in the catchment and can be used successfully to retain water on the contour, so preventing generation of surface runoff and promoting infiltration. However, the complex topography of the landscape can lead to convergence points and ultimately to breakthrough and soil erosion. Contour tillage can also concentrate flows onto the headlands where again flow can converge. The complex - and in places - steep topography also makes it difficult for operators to use machinery effectively – especially root crop harvesters.
- Restriction of row crops on steep slopes: Row crops are notorious for promoting overland flow especially when planted perpendicular to the slope. The steeper the slope the higher the potential of overland flow and surface erosion. Even if the crops were worked across the slope there is a risk on undulating topography, as found in the study catchments, that flow may be concentrated in a focal point leading to breakthrough and erosion (see above). Some land capability classifications recommend that permanent grass cover should be used on slopes steeper than 7^{o}. However, this may not be practicable or economically viable on farms where cultivatable land is limited.
- Wheel sizes and pressure/ restricting excessive heavy machinery use: The size of vehicles is increasing but this is limited by the size of field. Advantages of larger vehicles are that they require fewer trips to be made between field and farm therefore saving on travel time, fuel and repeated crossing of land. Restricting the weight of vehicles and/or reducing the pressure will help reduce soil compaction especially on wet soils which can be beneficial for late harvesting crops such as maize. There is still debate as to whether a

fewer number of trips with a large vehicle produces more or less compaction than a greater number of trips with a smaller lighter vehicle (Jorajuria and Draghi, 1997).

- Restrictions on the maximum amount of (liquid) manure application: Within the study catchments, the recommended maximum rate of application on high risk areas is 50 m^3/ha (MAFF, 1998). Slurry tends to have a lot of readily available N and can increase phosphorus (P), so increasing the risk of diffuse pollution by these nutrients if rainfall occurs soon after application (Smith et al., 2001). The incorporation of slurry should be done as quickly as possible when applied to bare soil (within 6 hours; MAFF, 1998), significantly reducing the risk of diffuse pollution. Increased use of organic fertilisers may also lead to the issue of pollution swapping[12] (e.g. faecal contamination and ammonium-N) if more manures and slurry are applied (ADAS, 2007).
- Restrictions of manure application to a certain time period: This technique is not applicable at the moment in the case study catchments, but is proposed to be introduced with new NVZs.
- Restrictions on the maximum amount of N-fertilisation: Restrictions on the maximum nitrogen application rate are imposed in NVZ. The area of land in the case study catchments designated under NVZ is set to increase (see Figure 10 in the Annex). Maximum nitrogen limit is calculated as the nitrogen applied in inorganic fertilisers plus the crop available nitrogen from organic fertilisers. The mandatory N limits are defined for specific crops e.g. winter wheat 220 kgN/ha, oilseed rape 250 kgN/ha, grass 360 kgN/ha etc. Recommendations for fertiliser applications in the UK are also given in RB209 (Defra, 2000).
- Restrictions on the maximum amount of P-fertilisation: Presently no maximum restrictions are imposed for the use of P-fertiliser although recommendations are given in RB209 (Defra, 2000). The Water Framework Directive, which is the main impetus for CSF, is driving the move to reduce phosphate levels within the case study catchments.
- Controlled livestock movement: Paddock systems are being trialled in the study catchments and offer potential for reducing soil damage through over poaching and over grazing. Moving the location of feeders and drinking troughs regularly or relocating them to a less sensitive location can also improve soil structural conditions (Heathwaite et al., 1990).

4.2.2 Long term measures

Longer term soil conservation measures with the potential to mitigate soil degradation in the case study catchments are shown in Table 8. Each measure that is considered appropriate to the case study catchments is considered in more detail below and can be compared to other measures using Table 8.

[12] Pollution swapping is where the management of one pollutant leads to the increased loss of another pollutant, for example the rapid incorporation of farmyard manures in to the soil, suggested as a method to decrease ammonia loss, can induce conditions that increase nitrous oxide emissions (Comfort et al., 1990).

Table 8: **Effects of long term soil conservation measures on soil degradation processes**

	Soil degradation process									
Measures	soil erosion water	soil erosion wind	decline in organic matter	negative carbon balance	diffuse contami-nation	compaction	salinisation	acidification	decrease of water reten-tion capacity	Off-site damage
liming					ne			1		0
drainage management to mitigate salinisation and/or compaction	1					ne				
controlled traffic tramlines	1					2				ne
retention ponds	1		0		2	0			1	2
hillside ditches	0		0		0	0			0	ne
subsoiling						2				
adjusting stocking rates	1				2	1				2
adjusting duration and season of grazing animals	1				1	2				1

Legend: The numbers indicate *the general effects of soil conservation measures on soil threats in the case study*, examined in questionnaire 1 with the following units: 2 = farming practice highly mitigates the threat, 1 = farming practice mitigates the threat, 0 = farming practice has no effect on threat and 'ne' indicating that it is dependent on other variables. The grey marked cells are not relevant because this measure has no relationship to the threat.
Source: ZALF

- Change of crop rotation: Some changes to the timing and introduction of cover crops have been reported in the case study catchments. Harvesting in early autumn enables the establishment of a cover crop that can significantly reduce soil erosion over high risk winter months. Early management of the crop also reduces the risk of soil compaction as the land can be worked when the soil is dryer and therefore less vulnerable to compaction.
- Strip cropping: Strip cropping is a technique used to reduce overall slope length by interspersing strips of close growing crops with row crops (Harris et al., 2004). While this is not widely used in the case study catchments one form of strip cropping is used. Strip cropping can include grass buffer strips most commonly planted as a linear feature at down slope end of fields so that they intercept surface runoff and trap sediment (Morgan, 1995). While these end of slope features can help reduce diffuse pollution of nutrients and sediment they could be more effectively if used within the field to shorten slope length and thus prevent initiation of overland flow.
- Use of organic soil improvers/exogenous organic matter: The use of soil improvers and exogenous organic matter was not reported in the case study catchments as most farmers had their own supply of farmyard manure. Improving soil organic matter, especially on the lighter soils found within these case study catchments will improve infiltration and water retention and strengthen soil structure.
- Liming: Lime is used in the study catchments to optimise pH levels to increase the efficiency of nutrients and organic matter. Adding lime may also have the added benefit of flocculating clay particles, forming a more crumby, open textured soil that will promote infiltration of water.
- Irrigation management to mitigate salinisation: not applicable in these catchments.
- Control of irrigation water/use of appropriate water quality: Not applicable in these catchments.
- Drainage management to mitigate compaction: While in the past the catchments would have been fairly extensively underdrained, this drainage has fallen into disrepair and is generally poorly maintained because of high maintenance costs. Improved drainage could help prevent soil compaction related to extended grazing season by maintaining a lower soil moisture content later in the year and could also help reduce damage caused by intensive summer rainstorms by increasing soil infiltration capacity. Issues relating to bypass of nutrients along artificial drainage channels would have to be considered.
- Controlled traffic tramlines: Compaction is a particular concern within the case study catchments and the use of controlled traffic tramlines could reduce the area of compacted land within the catchments. The system works by tracking (with GPS) or marking where a vehicle has moved in the field and using those same locations each time the field is driven over. This confines the compaction to the least possible area and by maximising the remaining area it is possible to reduce growers' costs and increases return.
- Chemical amendments: Not applicable in these catchments.
- Change of field patterns and sizes: The field patterns and sizes have changed very little over the past 10 years. Hedgerows that were removed to increase field sizes have partly been replaced. The average field size is relatively small (9.5 ha, Somerset). Although the reinstatement of additional old hedgerows would help reduce slope length preventing the build-up of overland flow and thus reducing erosion velocity.
- Retention ponds: These are an effective way of reducing runoff flows and related off-site damages (Posthumus et al., 2008). In a modelling exercise, Heathwaite et al. (2005) found that small ponds that store overland flow temporarily at the bottom of a field were very effective in reducing overland flow in the catchment following storm events. Experiences with a retention dam in a small agricultural catchment in Belgium also showed that on-site retention ponds were very effective, reducing the peak discharge and total runoff volume by 50 % and 40 % respectively (Evrard et al., 2007).

- Hillside ditches: Although these have not been installed specifically for runoff or erosion control, there are ditches at the edge of fields that carry any overland flow away, so preventing run-on to adjoining fields.
- Subsoiling: The use of subsoiling and aeration techniques to manage soil compaction is appropriate in most of the case study catchment area, providing the appropriate method is used e.g. subsoiling to eliminate plough pans and deep compaction and aerators to eliminate shallow soil compaction. Subsoiling is only effective when carried out at the correct depth (this varies from field to field) and when the soils are sufficiently dry at the critical depth to ensure optimum cracking and heave within the compact layers (Palmer et al., 2006). Soil conditions are seldom dry enough for subsoiling to be successful when carried out following late-harvested crops.
- Adjusting stocking rates: Lowering the intensity of animal production is only economically feasible if premium prices can be achieved for the product which in these catchments generally means converting to organic production. However, it is not feasible for all grassland farms to farm organically. This is mainly because it is believed that prices would fall as availability increased. Managing the movement of animals more effectively so that land is less over grazed and pasture has time to recover is a more feasible option for these catchment areas.
- Adjusting duration and season of grazing animals: There is a considerable economic pressure to extend the grazing season because of the high costs of silage and animal feed. These factors both increase the pressure exerted on the land and lead to reduced infiltration and greater surface runoff. Reducing the grazing season and/or the intensity of animals grazing the soil at wetter ends of the year would reduce structural damage in the catchment.

5 Evaluation of soil conservation measures

The evaluation of soil conservation measures examined 17 specific techniques. Of these, three (no tillage, mulch seeding and alley cropping) were not used in the case study catchments. The soil conservation measures that are being applied by farmers are described below along with farmers' and experts' assessment of these measures.

5.1 Cover crops/intercrops

While grass is used as a cover crop in the case study catchments not all grass is grown as a cover crop e.g. under pasture grass is the main crop. Other cover crops included rye grass after maize, cereal after maize and forage rape or mustard over winter between wheat and barley. In general, the practice of cover cropping or intercropping is not wide spread in the arable system.

Two of the interviewed farmers had introduced new cover crops into their rotation recently (<10 years) either following advice from FWAG or CSF officers or as part of converting to an organic system. Those farmers who used cover crops considered the cost to be relatively low because the crop either provides nutrients in the form of green manure, or a fodder crop that would have been grown anyhow. However, farm advisors suggested that some farmers may be put off because they perceived that the additional costs of seed and labour exceeded economic return within their system.

It was unanimously agreed by farmers and experts that cover crops protect the soil at vulnerable times and reduce runoff, resulting in lower nutrient and soil losses and consequently less diffuse pollution. Cover crops can also utilise nutrients that may otherwise be leached at vulnerable times. Sowing two crops in the same area (intercropping) increases the biodiversity of the field and may have additional environmental benefits in terms of additional habitat.

5.2 Undersown crops

Even though expert opinion considers the use of undersown crops, where a second shorter crop is grown at the same time as the main crop, to be highly beneficial to soil conservation, very few crops are undersown in the study catchments. Undersowing row crops such as maize can be effective in reducing soil erosion because it provides cover to an otherwise exposed surface. The main examples were undersowing maize or cereals (whole crop for silage) with grass. This has traditionally been used as a practice to ensure an early establishment of new grass leys. The main costs of the method relate to seed and cultivation, however, farmers dislike the method because it is not always successful and can reduce the yield of the main crop because of competition.

5.3 Reduced tillage

Reduced tillage, considered highly effective by experts at reducing soil erosion by water, is increasingly being used on conventional farms in the area because of the rising prices for labour in general and fuel in particular. Most farmers received advice on this practice from CSF officers, FWAG or their peers. Most farmers found the cost of adoption reasonably low because there was no need to purchase specialised equipment as they already had disk and chisel ploughs, although one farmer had found a specialised piece of equipment (shakerator) to be particularly effective. In this case the farmer had hired the equipment initially before committing to purchasing it. Reduced tillage also requires fewer passes with the machinery and therefore a lower fuel bill. Farmers in the Parrett catchment mentioned the threat of prosecution by the Environment Agency (under Water Resources Act 1991) and the issue of fines for sediment on the roads (under the Highways Act 1980) due to bad farming practices as another reason to adopt this practice.

The main benefits perceived by farmers were cost savings (labour and fuel). A reduction in runoff and a slight increase in crop yield were reported for cereals and maize in the study catchments. Farm advisors and experts agree that when used under appropriate conditions, reduced tillage can mitigate against soil compaction and surface sealing. However, under wet conditions, reduced tillage can cause soil compaction which can be reversed only by conventional tillage methods or subsoiling, as one farmer confirmed. While infiltration can be increased and diffuse pollution reduced using this method, use of herbicides to remove weeds is likely to increase, which may have wider environment impacts.

In the past, cultivation practices such as reduced tillage or leaving rough seedbeds were perceived to be bad practices among farmers (Posthumus and Morris, in press). Peer pressure therefore limited the uptake of reduced tillage, but this is changing because of changing attitudes to soil erosion and cost savings.

5.4 Ridge tillage

Although one farmer was familiar with the concept of ridge tillage, none of the farmers interviewed used the technique. Farm advisors reported that some potato growers in the area had tried this method but others had been deterred because of the need for specialised equipment. The technique has potential to reduce runoff and soil erosion considerably, although this is dependent on appropriate alignment of the ridges across – rather than perpendicular – to the main slope direction.

5.5 Contour tillage

Five out of the six farmers interviewed applied contour tillage, which was considered by experts to be effective at reducing soil erosion by water, improving water retention and reducing off-site damage in the case study catchments. However, this technique is restricted in the study catchments because of the size and shape of the fields. Most farmers who had

tried this technique had only done so recently after recommendation by advisors. They all considered the cost relatively low because no additional equipment was required and they would have had to plough the field anyway. The farmers all found the technique reduced runoff from their land. The technique can work well on simple slopes, but the complicated topography of the region can make working along a contour difficult (especially with regard to harvesting equipment), and increase the risk of water convergence at a point. If this happens there is the potential for breakthrough of the contour lines to occur, leading to down slope erosion from the breakthrough point.

5.6 Wheel sizes and pressure/restricting excessive heavy machinery use

According to experts increasing wheel size should appreciably reduce soil compaction. Three farmers use either a larger wheel size or dual wheels to reduce the loadings applied to the soil by the larger machinery. This has become common practice in recent years because the size of wheels has generally increased as farm machinery increased. Increased wheel size is perceived to reduce soil compaction, although it should also reduce rutting that can concentrate water accumulation. Reducing ground pressure is particularly beneficial to late harvested crops, such as maize, when it is important to minimise stress on potentially vulnerable soil structure due to wetness.

Adjusting tyre pressures to different circumstances was considered to be too difficult and time consuming, and this is therefore not applied by any of the farmers who were interviewed. More recently, farmers have noticed that contractors are also more aware of either using larger wheels or reduced pressure tyres. This is most likely as a direct pressure from farm managers. The cost of adjusting tyres was considered to be quite high because of the need for specialised tyres and the time needed to change wheels.

5.7 Fertilisation/pesticide application

According to expert opinion methods that reduce the amount of fertilisers or pesticides being applied to the land will appreciably reduce the risk of diffuse contamination. Under the organic farming system most farmers routinely monitor nutrient budgets in their soil and utilise organic fertiliser and green manures in the farm rotation to enhance soil fertility. Because of the rising fertiliser prices, conventional farmers are also increasingly interested in reducing inputs of inorganic fertilisers and they take advice from various sources to balance the nutrient levels. Other incentives are the requirements to comply with Farm Assurance or the option of nutrient budgeting within the Entry Level Stewardship (ELS) in which some farmers participate. Farmers generally found information readily available including nutrient management advice and nutrient management software [e.g. PLANET (http://www.planet4farmers.co.uk/content/aboutus.html) and Yara N plan (http://fert.yara.co.uk/en/)]. Five farmers considered the cost of soil testing was outweighed by the savings they could make by using less inorganic fertilisers. As a direct consequence of better nutrient management, the availability of excess nutrients in the soil has been reduced (Pers. Com., regional farmers), thus decreasing the risk of diffuse pollution. Encouraging more appropriate timing of fertiliser application will also help prevent nutrient loss, for example, applying fertiliser in early September when there is high uptake by most plants (ADAS, 2007). More localised and accurate timings of weather forecasts would also help farmers to apply fertiliser at optimal times.

5.8 Liming

Liming has been used traditionally in some parts of the study catchments to make nutrient uptake more efficient, by releasing nutrients in the soil. Some farmers have taken advice from agronomists and others have always traditionally used lime. Cost is perceived to be

relatively low because if pH is wrong then productivity levels drop. By applying lime, farmers can reduce the amount of fertiliser used, so the farmers feel this pays for the cost of buying lime in.

While most farmers suggested they apply lime purely to improve yield there is an additional benefit that was not mentioned. The calcium in the lime flocculates clay particles forming an open, crumby soil structure that allows better infiltration of water.

5.9 Irrigation

There is only limited use of irrigation within the study catchments and most of this is associated with potato production, where irrigation is used to improve the quality of the potatoes. To achieve premium prices the potatoes must be free from blemishes, and irrigation helps to prevent scab. The farmers are charged to extract water from springs and streams for irrigation purposes.

Irrigation of potatoes has enabled lighter soils on steep slopes to be used for potato production. These are high risk sites for erosion but most farmers believe the income benefits outweigh the risk of soil degradation and prosecution for bad land management practices. However, farm advisors and experts both agree that this risk is unacceptable and that this practice should be discouraged.

5.10 Control of irrigation water/use of appropriate water quality

The use of abstracted water is regulated by the Environment Agency and farms using river or ground water have to apply for an abstraction licence. Water quality can vary.

5.11 Drainage

Most of the drainage system in the study catchments is over 20 years old, corresponding to the cessation of government grants for new drainage back in the 1980s. While some drainage systems are still functional, others have been poorly maintained, or have led to shrinkage in peatland (under arable systems), and no longer function. According to expert opinion, improving drainage in the case study catchments should reduce soil erosion by water and also contribute to reducing risk of soil compaction. However, the initial costs of installing the drainage are considered to be very high by farmers, but once installed maintenance costs are low. Increasing the productivity of land and prolonging the growing season were major reasons for farmers to install drainage. One of the interviewed farmers reported installing new drains had enabled an extension of the period when field operations were possible. Another farmer reported that their land, which had old but functioning drains, allowed extended grazing into late summer because the drains reduced soil water conditions leaving the soil less vulnerable to compaction and poaching.

Farm advisors believe that better drainage could also help reduce the speed and size of peak storm flow response within the catchments, although this is disputed. The negative side of improved drainage within the catchment would be the increase potential for preferential flow of nutrients and sediments through the drainage system into local watercourses.

5.12 Contour cropping/grass strips

Very little contour cropping occurs in the study catchments, due to the complexity of the landscape (see above). Some farmers have installed contour grass strips, as recommended by FWAG or Defra. However, generally the farmers saw little benefit in doing it. One farmer mentioned that the cost of losing productive land is increasing with rising wheat prices.

The main cultivation / cropping pattern of the area is up and down slope within the field, with a 20 m wide header of crop running parallel along the top and bottom edge of the field. The

planting orientation of this last 20 m of crop may hold back water, but the length of slope above this headland (running up and down slope) will determine runoff volume and velocity. In some cases a 20 m wide header may be insufficient to prevent runoff generated up slope from running off the field (Pers. Com., regional farmers, Parrett catchment).

While, in the opinion of experts, contour cropping can help reduce the erosive power of surface runoff by holding back water and allowing time for infiltration to occur it requires careful management. On complex topographies it can be difficult to align perfectly to the contours and this can lead to convergence of water at a low point and ultimately to catastrophic failure, and down slope erosion from that point. Contour cropping is best suited to uniform slopes.

5.13 Field patterns and sizes

Hedgerows are a traditional field boundary feature in the UK. The South West region (where the case study catchments are located) has the highest density of these field boundaries in the country (SW Observatory, 2007). In the 1960s up to 1980s there was a trend to remove hedgerows in order to enlarge fields to accommodate the increasing size of farm machinery. Because of the dominance of pastoral farming system in the study area fewer hedgerows were removed than in other areas of the country. More recently the rate of hedgerow removal has declined, and the Hedgerow Regulations 1997 (http://www.opsi.gov.uk/si/si1997/19971160.htm) were introduced to protect important hedgerows from destruction or damage.

Some hedgerows have been replaced by farmers under various agri-environmental schemes (Country-side Stewardship Scheme, ELS). The cost of replacing hedgerows is quite high and grants only covered some of the costs, in the opinion of the farmers. One farmer reported that by reintroducing hedgerows and effectively reducing the slope length of a field, soil erosion had been reduced on fields with silty soils. However, hedgerow replacement is not widespread.

Farm advisors still considered large field sizes to be a problem within the study catchments and that benefits would be achieved through reducing field sizes, including increased soil erosion control, reduced flood risk and increased habitat for wildlife.

5.14 Crop rotation

Crop rotation is common practice within the study catchments, in order to reduce the build-up of pests and diseases and so reduce the requirements of herbicides, pesticides and fungicides. More recently, changing weather patterns (warmer autumns) and new, earlier ripening crop varieties have induced changes in crop rotations primarily relating to the timing of planting e.g. trying to harvest crop in late summer and early autumn in order to get another crop established while the soil is still warm (winter cover crop). For some crops, such as potatoes, the rotation period has also been extended to prevent skin blight.

As crop rotations are part of the farming system, costs to implement rotations are perceived to be low. Most of the crops in the rotation under conventional systems have an economic value, while some crops in organic systems are grown as a green manure, e.g. clover and mustard. Rotating crops has the advantage that the land is tilled relatively often and so compaction in the system is routinely removed as part of the rotation. Encouragement of well designed rotations that include break crops can reduce soil degradation and promote a more productive system.

5.15 Other

Subsoiling of arable land and aeration of grassland have been promoted by farm advisors in recent years to help tackle the problem of soil compaction. Farmers have reported better root development, increased yields and reduced surface runoff following subsoiling. One farmer reported a 25 % increase in crop yield following subsoiling and less runoff from the field. However, the increased fuel cost is an issue and would influence how frequently the farmer would be willing to subsoil or aerate their fields.

According to expert opinion, adjusting stocking rates and duration and season of grazing animals can applicably reduce diffuse contamination and compaction in the case study catchments. Of those farmers interviewed controlling stocking densities (taking livestock off the land when wet) and reduced trafficking on the fields because of larger machinery were also mentioned by farmers as practices that reduce soil compaction. However, housing livestock e.g. during wet periods (e.g. the summer floods in 2007), can be very costly, as farmers have to buy in extra feed.

One of the interviewed farmers had introduced a temporary paddock system, restricting animal movement to a specified area in the field by dividing a 6 ha field into 2 ha paddocks. The animals were moved to a different paddock after each milking. According to the farmer the advantages of this system include a higher proportion of lush grass in the animals' diet, less damage to soil structure and increased recovery time for the grass sward and soil structure. This type of system enables parcels of land time to recover in between grazing periods, simultaneously reducing the risk of soil compaction.

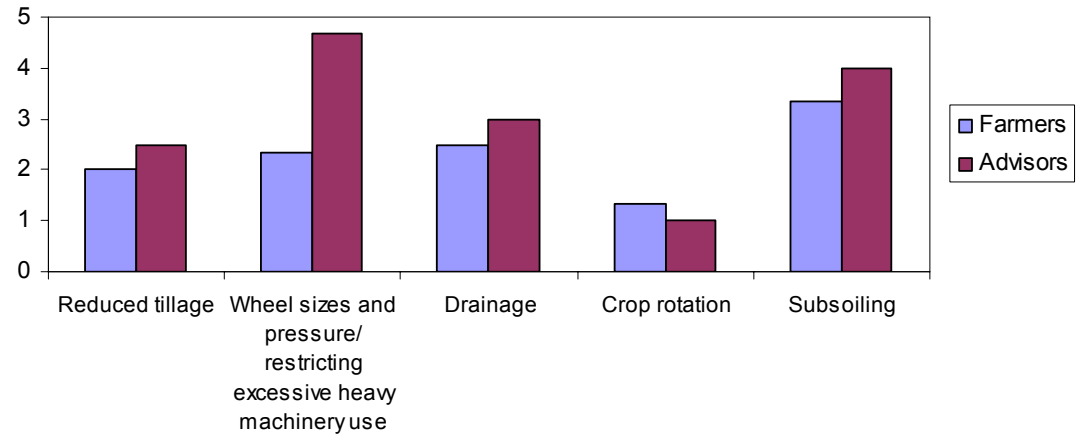
5.16 Conclusion

The technically most effective measures to control degradation processes in these study catchments are those that either reduce soil compaction or improve soil structural stability. In turn this will help improve infiltration capacity, increase soil water storage and reduce soil and nutrient losses. Methods such as reduced tillage, subsurface drainage, crop rotation and subsoiling could all be used effectively within these study catchments to improve soil and water conservation. The perceived cost of adopting these measures is shown in Figure 7. Crop rotation is perceived as the least costly of these techniques. Better management of crop rotations can protect the soil at vulnerable times, reduce chemical inputs by reducing weeds, pests and diseases, increase organic matter and nutrients in the soil and reduce soil compaction through tillage.

Better nutrient management is also essential to reduce excess nutrients in the system and associated diffuse pollution. By encouraging farmers to see farmyard manure as a valuable resource rather than a waste product, better nutrient management can be achieved. Farmers can reduce their inorganic fertiliser requirement, which represents a cost saving to them. Appropriate timing of fertiliser application is important to optimise plant uptake and avoid losses due to rainfall induced runoff. Improved, reliable, local weather forecasting is needed to aid better timing of fertiliser application. Appropriate use of a cover crop can also utilise nutrients that may otherwise be leached at vulnerable times.

The most important considerations influencing the adoption of soil conservation measures are economic factors (i.e. costs directly associated with any given measure, impact on output, impact on production costs) and, to a lesser extent, regulatory factors. Advisors (agronomists, FWAG, CSF, EA), peers and the farming press are important sources of knowledge dissemination. Unlike some other countries there are no cultural barriers preventing implementation of new practices. The main social factors that influence farmers in the UK case study catchments are other farmers and farm advisors, both of whom form social networks within the farming community.

Figure 7: Average perceived cost of adopting measures, ranked 1 (low cost) to 5 (high cost)



Source: Case study interviews. Data based on 6 farmers and 3 farm advisors.

6 Soil related actors

6.1 Actors in the farming practices arena

6.1.1 Description of characteristics and attitudes

Two distinctly different farming systems are found in the study catchments: conventional and organic. While organic farms represent only a small proportion of the agricultural area within the catchments they provide a good contrast between soil conservation under intensive and extensive management systems. The six farms visited as part of the survey ranged between 75 ha and 466 ha. There is a high percentage (approximately 80 %) of small farms (<50 ha) in the area (Defra, 2007a), but commercially viable farms tend to be >50 ha. In the case study area, of those farms of a commercially viable size 50 % ranged between 50 to 100 ha and the remaining 50 % were >100 ha (Defra, 2007a) The average sizes of farms in the survey were 112 ha for organic farms and 220 ha for conventional farms. The farming systems chosen were typical of the region: either pasture or mixed. The organic farms were typically grassland-based farms (pasture) with fodder crops.

Most of the agricultural land in the study catchments is owned and managed by family units and some agricultural land is rented either from other farmers or landowners who do not work their own land. Typically for the UK, most of these farms are independent businesses rather than part of co-operative groups. However, some of the organic farmers in the case study catchments do work in small co-operative groups to boost productivity. There are also initiatives operating in the area, e.g. Devon Rural Networks, South West Rural Enterprise Gateway and English Farming and Food partnerships, which offer networking opportunities to all farmers in the case study catchments.

Typically the farmers were second (or more) generation farmers who had supplemented their farming skills through national diploma schemes and/or by attending workshops and meetings. Management decisions in the last five years had often been influenced by FWAG and CSF advisors, although agronomists, Defra and NFU web sites, farming press and discussions with other farmers were also influential in decision making. Farmers were mainly

concerned about soil degradation processes when they led to loss of productivity, threat of prosecution or loss in grant payment. However, the farmers all expressed a desire to work their land in such a way that would conserve both its economic and environmental value. One farmer responded more positively with regard to protecting and enhancing the environment, while the other farmers were more pragmatic, selecting measures that brought the greatest returns for them. There were no obvious factors influencing this difference of attitude. Most of the farmers believed that they were managing soil conservation more effectively than some other farmers in the area, because of taking advice or trying suggestions. Comments from CSF officers suggest that it is the few farmers who do not engage with them that are more likely to cause diffuse pollution. The voluntary nature of the questionnaire and small sample size mean that it is possible that a biased sample is represented because farmers who are more open to taking advice may also be more likely to engage in feedback. There is no direct evidence for this except all farms who agreed to be part of the questionnaire survey also attended CSF workshops and/or meetings.

The farmers generally base their assessment of different methods of soil conservation on comparisons of productivity against cost of implementing the technique. The methods have to be economically viable in the system. Farmers are still prepared to take environmental risks in order to achieve a greater return e.g. potatoes grown on high risk land.

Most farmers felt they had had very little input to policy design or policy implementation, although one who argued for greater participation conceded that it could become impractical if space were made for too many opinions. One of the farmers did feel they had some influence on policy implementation due to their involvement with the local CSF liaison group.

6.1.2 Factors influencing adoption of soil conservation measures

Farmers were asked a number of questions about their view of the policies or initiatives seeking to influence their soil management and the answers can be understood in the light of the wider literature on the topic. Several studies have been undertaken to explain the adoption behaviour of farmers towards environmental practices. Morris et al. (2000), for example, found that arable field margins (promoted by Countryside Stewardship Scheme) have to be practical, offer adequate environmental and financial reward, and fit in with a predominantly commercial farm business purpose, in order to be attractive for farmers to implement. The known schemes, policies and initiatives aimed at soil conservation in the case study catchments are listed in Table 9, together with an indication of those actively used by the farmers. Uptake of these schemes was voluntary, sometimes taken up following advice from FWAG, CSF officers or EA. The main reason given for entering a scheme was for the financial payment associated with it e.g. ELS. Several studies in the UK show that most farmers enter agri-environment schemes for financial reasons while trying to minimise the impact on the agricultural enterprise (Wilson, 1996; Wilson and Hart, 2001; Walford, 2002). In some circumstances farmers have not had to make any changes in management but have been rewarded for activities they would do anyway (Colman, 1994). This happens especially in areas with extensive farming where few changes are required to comply with scheme requirements. The highest uptake of agri-environment schemes commonly occurs in less favoured areas (Kleijn and Sutherland, 2003). Those farmers in the case study catchments who chose not to enter into a scheme did so because they wanted to remain flexible in the face of changing markets and believed they could not achieve this if locked into Environmental Stewardship schemes of five years duration (see Figure 9 in the Annex). Most farmers choosing the Entry Level Stewardship scheme did so because they saw no economic advantage of going into the Higher Level Stewardship (HLS) scheme. Also, lack of funds for the HLS has meant farmers who should otherwise have been eligible have not been given funding under this scheme. According to farm advisors, the difficulty of entering the scheme in recent years has deterred other farmers from applying.

Table 9: **Farmers' awareness of, and subscription to policy measures, including schemes, voluntary initiatives and regulations**

Known schemes, policies or initiatives	Schemes, policies or initiatives actively involved in
Nitrate Vulnerable Zones	
Cross-compliance (CC)	✓✓✓✓✓
Single Farm Payment (SFP)	✓✓✓✓✓
Entry Level Stewardship (ELS)[1]	✓✓
Higher Level Stewardship (HLS)[1]	
Countryside Stewardship Scheme (CSS; being superseded by HLS)	✓✓
Organic Entry Level Stewardship (OELS)[1]	✓✓
Environmentally Sensitive Area (ESA)	✓
Water Framework Directive[*]	
Catchment Sensitive Farming	✓✓✓✓✓✓
Soil Association (organic certification)[13]	✓✓✓
Farming and Wildlife Advisory Group	✓✓✓✓✓

[*]Not mentioned by farmers, suggested by CSF officers
[1]Environmental Stewardship Schemes
Source: Case study interviews: (n=6).

The technical measures applied in the study catchments to improve soil conservation are a mixture of new and traditional practices. The new measures mainly (introduced in the last 2 to 3 years) include reduced tillage, contour tillage, ridge tillage and subsoiling. Of these, reduced tillage and subsoiling seem to be the most widely used. Some measures were more traditional, but being managed in a new way, for example fertiliser and pesticide application are now more precise on many farms with more soil testing and improved timing which has reduced excessive applications. Also, timing of crop planting and harvesting in rotations has been changed to protect the soil in wetter periods. Changes in wheel sizes are generally seen as an evolution associated with increasing vehicular size rather than a conscious effort at reducing the ground pressure of the vehicle. However, the importance of reducing ground pressure is not totally overlooked and it was reported that even contractors were being more conscientious about achieving lower ground pressures. Other measures that have been tried but were less favoured included undersowing crops and no tillage. Both methods were perceived to reduce crop yields so were not popular with many in the farming community. The most effective options were considered to be ploughing across slope, subsoiling, methods that increased soil organic matter and schemes that managed livestock movement on a parcel of land. The effectiveness of a measure was often perceived to be better if the farmer had also worked with a farm advisor (FWAG or CSF officer). Disappointment was expressed by farm advisors in relation to the Soil Protection Review under GAEC because it was seen as less effective than they had hoped. In their opinion Soil Protection Reviews raised awareness of soil conservation issues but farmers were not obliged to react to this information.

[13] In the UK, as elsewhere, organic farms have to be certified. The Soil Association (http://www.soilassociation.org/) is the UK's leading certification organisation for organic food and farming. To maintain certification strict compliance to guidelines must be adhered to and the farms and farm records are checked annually to ensure compliance is maintained.

Lack of flexibility offered to those participating in agri-environment policy measures e.g. Environmental Stewardship, Countryside Stewardship and to a lesser extent organic farming, was considered by farmers to be a problem. While there was some flexibility about what happened in different fields, the five year obligation under Environmental Stewardship was considered constraining for farmers who wished to be free to be able to respond to changing markets e.g. the sudden rise in wheat prices.

It was generally considered that most of the methods being used or promoted were technically good (they reduced soil compaction and runoff) and relevant to the region. However, there was some criticism by farm advisors that the soil conservation methods encouraged under ELS were too broad. Most farmers and advisors thought the measures were well designed, except for under CSF where grants were only available in priority areas of the catchment because of constraints on funding.

Cost is an important issue, with rising wheat prices farmers can at present make more money by ploughing up set-aside and grass strips than they get in payments for implementing agri-environmental schemes. While rising wheat prices are an issue, payments under ELS, HLS and OELS are regarded by farmers as just sufficient to maintain an economically viable system. Indeed, organic farmers believe that it is only the availability of the grants that makes milk production sustainable. However, one farmer argued that if grants were removed then supermarkets would be more willing to pay a more appropriate price for the product. Presently, because supermarkets know the subsidies received by farmers, the buyers believe this should be reflected in the price they are willing to pay the farmers for the product. Other relevant cost concerns amongst farmers arose from fears over the imminent introduction of new Nitrate Vulnerable Zones (NVZ). For present NVZ see Figure 10 in the Annex. Designation of a NVZ would restrict the timing and quantity of fertilisers that could be applied to the land. Fertilisers would have to be applied following recognised systems such as RB209 or PLANET. General record keeping would have to be improved, including the quantity, type, timing and nutrient value of fertilisers and manures applied. The restricted timing of applications would require additional public storage facilities for slurry. However, no additional public funding has been proposed for farms in new NVZ areas. The cost of installing 5.5 months slurry storage could be in excess of £150,000 (based on the extreme assumption of no existing storage).

Farmer opinions varied on the amount of paperwork involved with each scheme and this was partly linked to the perception of paperwork required on the farm in general, not specifically linked to agri-environmental schemes. Farmers thought they spent somewhere between 0.5 to 4 days a week dealing with paperwork. Some expressed a feeling of being inundated with paperwork and unable to “get on with farming”. However, those farmers who talked specifically about Environmental Stewardship paperwork suggested that although it took a day or two to sort out the initial paperwork, once the system was up and running there was less administration. Most felt that there was sufficient help available to those participating in HLS and Countryside Stewardship, but less initial help with ELS. Organic ELS farmers felt it had been difficult to get advice. Some felt there was too much advice and not enough time to go through it all. Therefore, they found talking things through with farm advisors (FWAG or CSF) was very helpful.

All farmers suggested they were aware of monitoring being conducted e.g. by the Rural Payments Agency (RPA) or Soil Association for organic certification, but few farmers were aware of specific monitoring related to soil conservation. Organic farmers, because of certification through the Soil Association, were most aware of soil conservation monitoring as were farmers who had problems that had invoked an EA response. The threat of enforcement seemed real to those farmers who were interviewed. All knew that non compliance could lead to prosecution or loss of payments. Farmers appreciated the more friendly approach that had seemingly been employed recently, whereby the EA would warn them of a potential breach and recommend working with the local CSF officer to resolve the issue. However, the perception of farm advisors is that farmers do not feel sufficiently

threatened by prosecution and this leads them still to take risks to achieve higher profits. The ineffectiveness of existing water pollution legislation enforcement was suggested as a major problem preventing effective prosecution.

Perceived gaps in policy included inflexibility regarding the preference for farmers to adapt to changing markets, policies not necessarily being appropriate to climate change considerations, missing landscape scale pathway controls and conflicts between schemes e.g. incentives to grow a specific crop to support a particular bird habitat that may not be appropriate to the risk category of the soil. Rather than identifying gaps in policies, some farmers felt that they were over-legislated and expressed the opinion that because of a few rogue individuals, all farmers were being targeted and being made to prove that they were farming in an environmentally sensitive way.

Farmers suggested that they would be more willing to adopt new schemes if they had seen other farmers using them, and had been able to discuss issues with these “pioneering” individuals e.g. on demonstration farms. They would also be more willing to try out new techniques if they were financially rewarded for it (insurance against loss of productivity) and provided that it did not commit them to any long term agreement. Farmers stressed that flexibility within schemes was very important to them. In a previous study, Davies and Hodge (2006) found two attitudinal factors to be important in influencing the level of support (or rejection) of cross-compliance: their orientation towards environmental stewardship and their preference for conventional agricultural technology. A third important factor was ‘situational stress’: farmers who perceive their land to be problematic to manage due to environmental limitations (e.g. heavy clay land or soil wetness) are less willing to endorse a governmental defined standard for farming practice. Farm advisors in the case study catchments suggested that more monitoring data is needed and that this data should be made available to the farmers so that they can take ownership of the problem.

Not surprisingly, policy and commodity markets appear to be important drivers explaining land management practices used by farmers in the catchments. Boardman et al. (2003) suggest that it might be relatively easy to induce changes in land management in agriculturally marginal areas by economic incentives. But to address erosion, flood and pollution issues on high value agricultural land is a more difficult challenge, as farmers here have little incentive to change their land management where it is successful in a short-term economic sense. In cases of conflicting objectives (intensive agricultural production versus conservation and reduction of pollution) farmers are less likely to adopt agri-environment schemes that conflict with their general approach to farm management. The present case study and other studies reveal that there is a complex of factors influencing farmers’ decision-making. These include their individual characteristics, attitude towards environmental stewardship, perceived environmental and financial benefits of participation, their compatibility with plans for farm succession and farm management, scheme flexibility, and the provision and communication of information and knowledge (Morris et al., 2000; Morris and Potter, 1995; Wilson, 1997). However, none of these factors are consistently decisive for all farmers or circumstances.

6.2 Actors in the policy design and implementation arena

The conservation and protection of soils is being recognised as an increasingly important policy objective in England. The relevant actors are taking steps to review the policies currently in place, with the aim of better integrating and applying the policy response to soil degradation, and identifying extra measures and policy options where appropriate. Increased monitoring & consultation is central to this process.

The different foci and objectives of policies relating to soil conservation, and their disparate administrative approaches, can lead to gaps in intervention and therefore the overall effectiveness of these policies in achieving soil conservation objectives. Thus it is particularly important that the relevant policies work in concert, and so do the relevant actors in policy design and implementation.

All stakeholders interviewed made clear reference to two groups of actors in policy design and implementation, with differences in approach, extent of influence and tendency to work separately or together to achieve effective soil conservation policy. These two groups can be classified as 'governmental organisations', and 'civil and non-governmental organisations'.

Interviews were conducted with both groups of actors, further distinguishing between those who operate at the local/regional level in the case study area, and those which operate at the national level. The opinions and positions of these two sets often differ.

6.2.1 Governmental organisations

The regional and national stakeholders interviewed (see Annex), agree that governmental organisations exert the greatest influence on soil conservation policy design and implementation, both in the case study area and in the national context.

Primary amongst these is the **Department for Environment, Food and Rural Affairs (Defra)**, which is the governmental department in charge of agriculture as well as the environment and is responsible for delivering soil conservation policy in England. Recent soil policy can be traced back to the Government's 1999 publication, 'A Better Quality of Life'. This advanced the issue of soil protection as a policy objective, and although stating that 'soil quality is not a major problem in the UK'[14], proposed that soil protection should be given equal priority to that of air and water in the future, with a focus on minimising the loss of soils to urban development. It also announced that a draft soil strategy for England and Wales would be released, which followed in 2001 as the MAFF/DETR draft Soil Strategy, a consultation paper sent to a wide range of relevant organisations.

Defra replaced the previous agriculture ministry (MAFF) in 2001 and a dedicated Soils Policy Team was installed as part of the Environmental Land Management Division, in 2003. This is still a small team within Defra, which operates in consultation with other relevant departments, specifically those responsible for environmental land management, sustainable development, arable crops, better regulation, wildlife & countryside, climate change, and water. A soil programme has been initiated to foster and maintain these relationships, though it is very much in the early stages, with an over-seeing Board that has yet to meet (Pers. Com., Defra Soils Policy Team). A lot of importance is placed on these departments working closely together and across government.

These Defra departments, along with relevant semi-autonomous government agencies, notably the Environment Agency (EA), Natural England (previously English Nature), the Rural Payments Agency (RPA), and the then Rural Development Service (RDS) first met as a working group to consider future policy options for soil protection and conservation in 2003. A subsequent decision was made by Defra to make a priority of increasing the understanding

[14] http://www.sustainable-development.gov.uk/publications/uk-strategy99/08.htm

of soil conservation issues across the farming (and policy) community (Pers. Com., Defra). The first Soil Action Plan for England, launched in May 2004, sought to advance this priority by including the development of a programme to improve the education and awareness of soil issues as one of its three main aims. The other two were to ensure careful soil management, and to develop regulatory approaches to soil protection. A total of fifty-two actions were set out, with thirteen core actions, to 'tackle issues at the heart of' the three aims.

The objective of increasing education and awareness of soil protection and conservation issues has subsequently been delivered by Defra through workshops, newsletters, articles, and by a strong emphasis on stakeholder consultation in soil policy design. The ongoing Soil Action Plan Advisory Forum was established in November 2004 to provide a mechanism for its twenty four[15] governmental and non-governmental stakeholder organisations to present their views on the progress and implementation of the Action Plan, and constitutes a platform to provide advice, ideas and feedback on designing and developing policy. In addition to the Forum, Defra is keen to promote interaction and consultation with a wider stakeholder community, including those with farming and scientific interests.

The EU Thematic Strategy on Soils was in development around the same time as the initiation of the Soil Action Plan, in 2003. The Thematic Strategy consisted of a Communication from the Commission, a proposal for a framework Directive, and an Impact Assessment. Defra officials (Pers. Com., Defra Policy Lead and Soils Team) consider that the steps being taken towards developing soils policy in England were independent of the European approach (i.e they were driven by national objectives), but that the Thematic Strategy complemented the priorities and targets that Defra were developing. This provided an opportunity to combine strategies, whilst ensuring that domestic action kept in line with the proposals.

The Environment Agency (EA) is a partly autonomous public agency with its own Board, but which reports to Defra. It is widely recognised as a major actor in soil conservation policy, both through implementing policy itself, and through working and consulting with Defra. The publication in October 2007 of 'Soil: A Precious Resource', the EA's 'strategy for protecting, managing and restoring soil'[16], highlights the EA's recognition of soils as an increasingly important area for management and policy. The document sets out the Agency's multifarious role in soil conservation policy, which includes the provision of technical advice to Defra on policy development; the implementation of policy on the ground; the enforcement of sanctions for non-compliance; the assessment and reporting of impacts of soil management; and the provision of advice to stakeholders. The EA acts primarily as a partner to Defra, providing consultation and implementing policy decisions, though it does not generally take lead responsibility[9] in these areas.

A substantial focus of the EA's work is on water resources and protection. One of the key priorities for soil conservation is to integrate the management of water, air and soil, and another is to address the link between water and soil in an agricultural context, specifically to reduce diffuse pollution from agricultural soils into water systems. This is a central requirement for implementing the EU Water Framework Directive, which forms a backdrop to many soil-related policies in the current climate, including Catchment Sensitive Farming (CSF). However, the link between soil and water is not the EA's sole objective in relation to soils, and it also lists as a high priority the improvement of knowledge and accessibility of information on soil management to stakeholders ([9], Pers. Com., EA), as well as improving the understanding of soil biodiversity.

15 http://www.defra.gov.uk/environment/land/soil/sap/sap-advisory/members.htm

16 http://publications.environment-agency.gov.uk/pdf/GEHO1007BNDB-e-e.pdf?lang=_e

The relationship between the EA and Defra is one key to the successful implementation of soil conservation policy in England, and the EA make frequent reference to this relationship in its published objectives, as well as in the case study interviews. Staff hold regular informal meetings with Defra on policy consultation and approaches (Pers. Com., Defra, EA). Consultation and interaction with other organisations and stakeholders is also prioritised, and realised through steering groups such as the Soil Action Plan Advisory Forum, and in local-level advisory workshops. Consultation, improvements in regulation, and the provision of advice to stakeholders, are the EA's key priorities on agricultural soil conservation.

The Environment Agency (EA) is widely cited as being the most influential governmental actor in policy design and implementation in the Axe and Parrett catchment areas, both in terms of local policy and initiatives, and in the wider aspect of the Agency's national policy. The EA takes an active role in organising and delivering region-specific schemes and advisory services (e.g. CSF), and is the regulatory agency responsible for implementing a number of command and control functions and farm inspections, seeking sanctions through the courts for non-compliance where necessary. The fact that the work of the EA is often guided or dictated by national or European policy through Defra, or directly from EU legislation, was recognised by many regional stakeholders. However, the EA has a more tangible presence in the catchment areas.

Stakeholders operating at the national level are more aware of the organisational role which Defra plays, both directly in soil policy design and implementation, and in organising the roles of the EA and other policy actors, from their top-down position.

Natural England (NE), another semi-autonomous government agency reporting to Defra, also plays an influential role in this policy area, within the objectives of the conservation and enhancement of the natural environment as priorities. NE is responsible, under the direction of Defra, for the delivery of Environmental Stewardship (ES), England's primary agri-environment measure within the (EAFRD) framework, and it also plays a significant design and implementation role in the CSF scheme. Along with the EA, NE provides Catchment Sensitive Farming Officers (CSFOs) to provide technical advice and support within the scheme's forty priority catchments, including those of the Axe and Parrett. NE engages on a regular, high-level consultative basis with Defra and the EA, both as part of the Soil Action Plan Advisory Forum, and in its own right.

The Rural Payments Agency (RPA) is the executive government agency acting as the national paying authority for the Single Payment Scheme (SPS). The RPA administers the scheme and with that, is responsible for the inspection of cross-compliance standards associated with the beneficiaries of the scheme. The SPS application form includes a checklist for SMR and GAEC standards for completion by the farmer, and the RPA performs random inspections of farms to ensure compliance. If non-compliance is identified by an inspection, reductions to the SPS payment are applied by the RPA as part of the administrative process. The RPA consults NE on the administration of rural development schemes, including ES, to ensure that compliance with each scheme's regulations does not breach either CC or ES standards; if breaches are identified, the RPA administers reductions to the SPS payment. The RPA also engages in consultation on soils policy via the Soil Action Plan Advisory Forum and more informal meetings with the Defra Soils Policy Team.

6.2.2 Civil society and non-governmental organisations

Numerous civil society and non-governmental organisations, including farming and technical advisory agencies, charitable NGOs, and research institutions contribute to policy either directly or through consultation forums. The most important actors in this group provide technical and advisory resources, and relay messages between farming actors and policy-makers to inform policy design and implementation. There are region-specific actors in the Axe and Parrett catchment areas, but in most cases these actors operate on a national (or more extended) basis.

Many stakeholders consider that advisory bodies and member organisations are influential in increasing the effectiveness of government intervention in soil conservation, and with that, specifically in increasing the effectiveness of policies in the catchment areas. The roles of these advisory bodies - namely the Farming and Wildlife Advisory Group (FWAG), the National Farmers' Union (NFU), the Agricultural Development and Advisory Service (ADAS), the South West Rural Development Agency (SWRDA), West Country Rivers Trust (WCRT), and local agricultural and technical experts/consultants - are effectively twofold. First, they provide advice and assistance to farmers, on one-on-one and group bases. This is often an explicit objective of policy implementation, wherein the advisory actors can be financed directly by provisions within policy initiatives such as CSF. Secondly, these bodies provide advice and feedback from the ground level to the governmental organisations, through measures such as the Soil Action Plan Advisory Forum, and other consultative roles. This consultation includes the provision of technical data and expertise from monitoring initiatives and research, and the feedback of opinions and proposals from the farmers and land managers with whom the advisory bodies interact or represent.

In addition to the advisory bodies, environmental NGOs (such as the wildlife trusts), private water companies and independent technical experts were recognised for their involvement in the policy process. These organisations do not deliver management advice to farmers, but they are involved in the consultation process, sitting on local CSF steering groups and the Soil Action Plan Advisory Forum, and are invited to participate in Defra's consultation on the draft Soil Strategy for England (see Section 6.2.3). They provide specific and technical advice to inform the policy review process, and their involvement in this process is recognised and valued by Defra, the EA, and the organisations themselves (Pers. Com., Defra, EA, NFU, NT, RSPB).

There is, however, a concern from regional interviewees, particularly the advisory bodies, that although there are forums at which regional actors can raise and discuss opinions and results of studies and policy initiatives, these messages are not always delivered to the national level, and therefore do not have sufficient influence on national policy design and implementation (Pers. Com., FWAG, regional NFU Policy Adviser, independent advisor, water companies).

6.2.3 Resources, capacities and networks

6.2.3.1 Policy design

The importance of European legislation is recognised by all stakeholders, including Defra, as it directly influences the manner in which policy is designed in the UK. The Common Agricultural Policy (CAP) sets the framework for Member States (MS) to operate their Single Payment Scheme (SPS), cross-compliance (CC) conditions and rural development programmes (RDPs), and to a large extent influences the size of their agricultural budget. EC Directives, transposed into national legislation, directly dictate the design of national policies on soil conservation.

The subsidiarity principle allows national authorities the flexibility to tailor certain policies to national requirements, particularly in RDPs. In the case of cross-compliance, Defra chose the GAEC standards relevant to soil conservation from a menu set out in EC Regulation 1782/2003, within which significant flexibility of options is afforded the MS. A number of Defra departments (see Section 6.2.1), as well as external stakeholders, were involved in the decision process on the standards put in place. The Soil Protection Review (SPR) requirement is considered to particularly incorporate the key priorities that emerged, and although there were tensions in the design process, a consensus was reportedly reached easily (Pers. Com., Defra).

The Defra Soils Policy Team considers that working in a coordinated manner across different parts of the ministry is efficient, and the division of responsibility gives them the ability to

make changes in soil policy with a wider, and therefore more informed, perspective (Pers. Com., Defra). However, this view is not held by all stakeholders, as many perceive that a more centralised approach from a single, dedicated department is necessary to give clear direction in policy design (Pers. Com., regional NFU).

Defra is keen to promote the importance of national stakeholder consultation in the design of soils policy. The draft Soil Strategy for England sets out the priority areas and a series of proposals for designing and delivering this policy. It was sent for consultation to one hundred and fifty consultees for their opinions and input on the proposals[17]. Defra officials (Pers. Com., Defra) are positive about the relationships forged through the Soil Action Plan Advisory Forum to which it reports on progress towards meeting policy objectives, and consider that the consultation process is essential to inform effective policy design. In turn, Defra must provide reports to the Forum on the progress of policy towards meeting objectives (see Section 6.2.1).

Outside of this Advisory Forum, Defra (Pers. Com.) engages in more informal consultation with the policy delivery agents (EA, NE, RPA); the farming community; land managers including conservation organisations such as the National Trust; environmental NGOs; and research councils and institutes. A senior Defra official stated that Defra works closely with these bodies from the policy preparation and development stage, so that their expertise and opinions are engaged from the outset.

Information from farm surveys produced by the farm advisory bodies Momenta and ADAS provides Defra with feedback on uptake of measures and the perceptions of farmers towards policy, and on the effectiveness of farming practices. The RPA provides reports on farm inspections under CC, including the reasons for any non-compliance, which are not numerous but are considered informative (Pers. Com., Defra). It is recognised that information from stakeholder forum consultations is primarily based on qualitative analysis and opinion, and that it needs to be supported by technical and scientific monitoring. A Defra review of CC is currently underway (undertaken by CSL and Gloucester University), and a specific review of how GAEC standards affect agricultural soils is being undertaken by the Defra Soils Policy Team (Pers. Com., Defra). These are recognised by Defra as difficult but important procedures.

To a large extent the organisations which take part in these consultations at the national level agree that the system works well, and they are pleased with the input that they have had in policy design (Pers. Com., ADAS, EA, NFU, NT, NE, RSPB). ADAS is funded by Defra to produce the Soil Erosion Manual as the best practice guidance for farmers, which underpins the SPR. It also conducts extra research on specific soil management techniques. ADAS considers that this research increases Defra's understanding and awareness of farming practices and impacts, and is used effectively to inform policy decisions (Pers. Com., ADAS).

In the Axe and Parrett catchment areas, the same advisory bodies and NGOs contribute to stakeholder discussions, with a particular focus on the CSF, for which steering groups are organised three or four times a year by the EA and NE. The vast majority of local stakeholders interviewed were involved in this consultation process, and many feel that at this level their involvement influences policy design, and that they are given suitable opportunities to do so (Pers. Com., FWAG, NFU, RSPB, SWW, independent advisors). The focus is on tailoring measures to the soil degradation and farm management requirements of the catchments. Responses initiated through the CSF include farm visits and workshop demonstrations to farmers, for which organisational and delivery details are designed through this consultation. NE and the EA are responsible for administering these initiatives and for managing the roles of the advisory bodies, once the consultation has set the direction.

[17] http://www.defra.gov.uk/corporate/consult/soilstrategy/list.htm

Monitoring data to evaluate the effectiveness of CC measures on soils has been criticised as inadequate (IEEP, 2007), although research on indicators for soil attributes and approaches to modelling soil erosion risk are being developed in England. Defra will build on the SPR standard particularly, in a review of CC being conducted at the moment (Pers. Com., Defra). Consultation with the Soil Action Plan Advisory Forum and other informal meetings with advisory bodies are used to review whether any of the standards require revision or addition, and farmers' understanding of cross-compliance is monitored through an annual survey, conducted for Defra by an independent company, Momenta.

There are, however, concerns within the Defra Sustainable Farm Management Team that no matter what the recommendations of the national review, the EC considers that England already has relatively demanding CC standards and that there may be resistance from the Commission to any further raising of standards in England, in order to 'keep a level playing field with other MS' (Pers. Com., Defra).

A lack of good monitoring data, about either soil condition the impact of schemes addressing soil management is an impediment to policy development. The main reasons for this are:

- soil conservation policies have been established relatively recently;
- the variability of soils (both geographically and temporally) requires particular sensitivity to local conditions;
- the unpredictability of soil characteristics (e.g. fluctuations due to extreme weather conditions) requires sensitivity in the policy response; and,
- the long-term nature of changes in soil characteristics (5-20 year timescales) leads to a need to tap considerable external experience and expertise.

The consultation process in CSF is considered an effective and targeted method of policy design by stakeholders in the catchment areas (Pers. Com., FWAG, NFU, RSPB, SWW, independent advisors). This is reflected at a national level, where baseline surveys of CSF farmers across the forty national priority catchments in England in January/February 2007 and November 2007, reported that farmer engagement was highly effective, in terms of increased knowledge and awareness of soil degradation processes and farm practice responses. This is judged to have had a positive effect on soil management (see Section 7, Fiche 3 for details of evaluation). Engagement with farmers is considered by Defra to be the main objective of the Initiative[18]. Voluntary approaches, in particular CSF, are seen as the most effective policies by stakeholders through raising awareness and understanding of the environmental and economic issues amongst farmers. Farmers and civil society/NGO stakeholders favour the design of CSF because it is targeted to their specific catchment area, and it initiates, and in turn relies upon, their own interaction and involvement.

At the local level, many consider that more focus in policy design should be placed on this stakeholder consultation so that bottom-up approaches and evidence, and particularly landowner perspectives, are integrated more in policy at the national level. Every stakeholder interviewed in the Axe and Parrett catchment areas thought that this bottom-up, participatory approach is key to effective policy design, so that if problems or successes are identified at the local level, they inform national policy design. However, most hold the opinion that this upward influence is not happening currently, and that little feedback is received from Defra and the EA (national level) to suggest that the perceived successes and failures of CSF in the Axe and Parrett are being used to inform national policy design (Pers. Com., FWAG, regional NFU, independent farm services advisor, SWW).

[18] The Catchment Sensitive Farming Delivery Initiative report / website: http://www.defra.gov.uk/news/2008/080603b.htm

Defra can demonstrate, however, that the success of CSF initiatives and its local focus is recognised, as the scheme has recently (June 2008) been extended for at least three years.,[19] The emphasis which Defra places on consultation in policy design is significant, and a major basis for the CSF extension was a baseline survey of one thousand CSF farmers, so the claim that Defra is not utilising local-level opinions and evidence bases in policy design can be disputed. Increasing the level of communication between Defra and the catchment actors on how their interaction is being utilised, might help to address these local concerns.

Whilst stakeholder consultation is clearly embedded in CSF policy design and future initiatives, it has been more problematic to utilise data from the monitoring and evaluation of soil characteristics, and therefore evaluate the effects that CSF measures have had, particularly as CSF has only been implemented for two years. Defra is looking to instigate reliable indicator and monitoring systems to address this deficiency in empirical information (Pers. Com., Defra).

There is a link between the locally grounded approach within CSF and the local delivery of Environmental Stewardship (ES). Technical measures and advice provision within CSF are designed to align with, and help to deliver, ES agreements with farms, both to assist those farmers involved in both schemes, and to ensure consistency of management practice across a catchment. The design of ES policy at a local level follows similar lines to that of CSF, by engaging regional stakeholders in consultation. .NE is responsible for delivering both schemes so an integrated approach can be designed (Pers. Com., NE, national). Early consultation is considered key to inform effective policy design, and stakeholder meetings are regarded as regularly well attended with a good, representative view from all organisations (Pers. Com., NE, national). Individual farmers are not involved in their own right in these meetings but are represented by member groups and importantly by CSFOs, who report uptake levels, opinions, and qualitative results from CSF catchments to ES policy makers at NE. This process of representing and reporting is considered by NE to be a very effective method of obtaining information crucial to policy design.

Agri-environment measures evolve over time and the development of ES was an inclusive process led by Defra in close consultation with its statutory agencies, farming organisations and relevant environmental NGOs. The process was overseen by the Agri-Environment Steering Group and smaller working groups were set up to develop particular elements of the scheme. All of these groups included key stakeholders, and a number of full public consultations were also carried out. A national Review of Progress of ES was completed in May 2008. This was led jointly by Defra and NE but included four national stakeholder events. The topic-specific working groups also included key stakeholders.

ES policy design of course, draws on various sources of information beyond the consultation process, including GIS observation and other monitoring data to target areas for particular prescriptions (e.g. reversion of arable land) (Pers. Com., NE, national). NE Officers make decisions on how and where exactly to target the measures, and deliver advice appropriately. Evaluation is subcontracted to independent organisations, including a recent eighteen month evaluation of the scheme, performed by CSL, and another by ADAS on more qualitative analysis from stakeholders. Most feedback from this review was considered positive, and if critical, constructively so (Pers. Com., NE, national). For example, there was a suggestion to move the popular, 'no-risk' measures from Higher Level Stewardship (HLS) into Entry Level Stewardship (ELS) (see section 7.2.2, Fiche 2). These suggestions will inform future ES policy design, but through a rather lengthy process (Pers. Com., NE, national).

There has been an important point of tension between the voluntary approach in ES and the mandatory one embodied in CC, on which the European Commission intervened. In the version of the ELS available to farmers prior to the current generation of AEMs in the 2007-

[19] The Catchment Sensitive Farming Delivery Initiative report / website: http://www.defra.gov.uk/news/2008/080603b.htm

2013 Rural Development Programme, participants could receive a payment for drawing up a voluntary Soil Management Plan (SMP), with some of its prescriptive measures potentially eligible for ES funding. This option was included in the draft ES measure presented to the European Commission in 2006/07, but was rejected on the grounds that it did not add significant value to CC measures, notably the SPR. The Consultation on the draft Soil Strategy for England links ES very closely with CC, and underlines the relationship between the SMP and the SPR. It suggests that they are effective together and proposes the investigation of 'the extent to which Entry Level Stewardship (ELS) might contribute to delivering, in combination with CC, the requirements of a Soil Framework Directive'[20]. The withdrawal of the SMP and the relative effectiveness of these two approaches to motivating and planning soil conservation are still topics of debate and uncertainty, within Defra, NE and elsewhere.

Defra's viewpoint is that the aim of the SPR is for farmers to understand the condition of their soils, the impact of their management practices, and the remedial actions they need to take to maintain soil structure, organic matter and to prevent soil erosion, using a whole farm assessment approach. The SMP was more specific on the management of individual fields, and is considered to contain a more technical and scientific assessment of farmers' soils and be more suited to a voluntary approach (Pers. Com., Defra, NE, national). Defra recognise benefits from both measures, suggesting that although the SPR is a less technical and scientific method, the approach still retains sufficient technical analysis. One proposal is for the SPR to combine the three further GAEC standards (see section 7.2.1 Fiche 1), as well as the SMP's approach, into one easier package for farmers to follow, with guidance and policy/practice updates provided regularly (Pers. Com., Defra Soils Team).

A national-level NE official considered the removal of the SMP as a negative step, as it aided farmers' understanding of soil degradation processes on their own farms. However, a NE CSFO considered the opposite, because completion of the SMP could be performed by consultants paid via a grant, which potentially meant that farmers did not need to understand or follow the measures themselves. The mandatory SPR requires a personal understanding of the process, as advisory services are not provided or funded under cross compliance (Pers. Com., NE, national, NE CSFO).

It is not universally accepted that the SMP was superfluous to the SPR, nor that it should have been removed as an ES measure, as both the SMP and SPR are considered to provide distinct benefits (Pers. Com., Defra, NE national). A review of the SPR is underway to consider how some of the benefits of the SMP can be retained through agri-environment measures, and integrated into a more technical approach to soil management. A Defra official states that, 'The SPR looks at problems and risks, then plans in advance how to manage them, and we are looking at ways of incorporating these benefits into changes in agri-environmental options' (Pers. Com., Defra Soils Team).

6.2.3.2 Policy implementation

Defra's Consultation on the draft Soil Strategy for England (March 2008) cites four policies as having 'contributed to raising the awareness of land managers of the impact of their actions and providing guidance on best practice for future soil management'[21]. These are cross compliance (CC), Environmental Stewardship (ES), Catchment Sensitive Farming (CSF) and work towards the implementation of the Water Framework Directive (WFD). Indeed these are the four policies most frequently identified by interviewees as important to soil conservation in the case study region, and nationally. There is some consensus that none of these measures alone can encompass all the aims of soil conservation, but opinions on the relative merits of the four policies differ.

---

20 (consultation on Soil Strategy)
21 (consultation on the draft Soil Strategy for England)

Cross Compliance is noted in all interviews as being particularly important for two reasons. First, receipt of the SPS is conditional on compliance, so standards are generally adhered to, and as almost all farmers receive the SPS, there should necessarily follow a high uptake of these measures. Second, CC is perceived by some, particularly at the national level, as being the most effective policy in terms of its impact on agricultural soil management and the condition of agricultural soils, although this is not necessarily reinforced by empirical evidence.

The inspection regime appears to provide farmers with the motivation to comply, although it is clear that compliance with standards that require some form of record keeping are easier to check than those that rely solely on visual inspection. The effectiveness of cross-compliance is debated by the regional stakeholders, in terms of the strength of the measures involved and also the method of their implementation, which many see as weak due to the limited element of targeting in the enforcement. Evaluation work suggests, however, that cross-compliance has increased awareness of both the environment and their obligation system among farmers. Due to the time lag between policy implementation and environmental outcomes becoming observable, it is not yet possible to state with any certainty what the environmental impact has been, although it can be expected to be positive given the high rate of compliance (IEEP, 2007).

ES (ELS & HLS) is administered by NE. Unlike CSF there is no one-to-one advice provision for farmers, but workshops and group advice, as well as leaflets and information, are provided via NE's Conservation Advice Programme, delivered by ADAS and FWAG, with a budget of approx. £1.2 million/year.

In order to be eligible for ELS, the applicant's land must be registered on the Rural Land Register by the RPA. Applicants are required to fill in a Farm Environment Record (FER) which identifies key landscape features on the farm (it is a condition of the scheme that these features are identified, mapped and then retained) and also areas at risk of soil erosion and runoff. If such areas are identified, the handbook recommends the relevant options available within the scheme that would be appropriate to choose in order to address the risks. The applicant is given a scheme points target for their holding (number of hectares multiplied by thirty) and must choose sufficient ELS options, each associated with a number of points, to meet this points target. Currently, farmers have a free choice from a menu of over fifty options, which need to be marked on an 'options map', however the recent review of progress has recommended changes to this. The application, including relevant declarations, is sent to Natural England for processing and if all forms are correctly filled in, with the points threshold met, an agreement will be issued.

HLS is a highly targeted, discretionary scheme. Management options are focused on maintenance, enhancement and restoration of features and habitats, and aid for capital works is included within the scheme. Applicants to HLS normally have to either already have an ELS agreement, or be entering ELS at the same time, as ELS is designed to underpin HLS. Farmers are required to fill in a Farm Environment Plan, setting out the key environmental issues/features on the farm and the priorities for management. Depending on whether these fit with the local targets for the scheme then applicants are advised on whether it is worth making an application. Applications are generally made with the help of specialist advisers which can come from a range of organisations, including FWAG, RSPB, and the local Wildlife Trust. Farmers can choose from a range of options, but those chosen should be focused on features identified within the Farm Environment Plan (FEP). Each option has some prescriptions associated with it and an Indicator of Success which identifies the targeted outcome. Once a set of options have been chosen, these are developed into an application, which is submitted to Natural England and assessed on a quarterly basis in relation to the environmental targets and the available budget. Not all applicants are accepted.

All interviewees at the local level see CSF – or similar targeted, voluntary initiatives – as the favoured approach to soil conservation policy, even though its primary objectives, as its name suggests, concern water systems, and many of the scheme's aims are seen to be driven by EA flood risk plans, and catchment and water body management in light of the WFD (Pers. Com., FWAG CSF Officer). However, agricultural soil management is an explicit priority of the scheme, necessitating engagement with landowners on soil degradation and conservation issues. Presentations, discussions and demonstrations on the objectives of the policy and the effects of farming practices are given on one-to-one and group bases. These events are organised and delivered by the CSFOs. All local Government and civil society/NGO actors believe that this is the best method for implementing soil policy, but impressions do differ on the methods behind the approaches.

In terms of resources, concerns are expressed over the skillsets of farm advisors, with a number of stakeholders considering that although many farm liaison officers are very effective in their role, extra training is required to ensure that all are of a standard high enough to ensure effective advice is always delivered (Pers. Com., EA, FWAG, independent farm advisor, regional NFU). Concerns over financial resources and the uncertainty of funds to ensure the continuation of the CSF scheme were also expressed, but these are no longer a pressing concern since Defra announced the continuation of the CSF scheme until 2011, with funding of £12.9 million in 2008-09, of which £5 million is for capital grants. Funding for 2009-10 and 2010-11 will be confirmed as soon as Defra completes its business planning for these years[22].

Whilst there is strong local support for CSF, effective monitoring is still required to measure results and make an appraisal of cost-effectiveness. Information/awareness campaigns and technical assistance measures might depend on this empirical foundation for their success where there are potential "win-win" solutions for both environmental and production objectives. Outcomes are often uncertain and need to be tested[23].

There are several schools of thought concerning the best means of improving policy implementation. One widely held opinion is that financial resources are too low or not consistent enough to deliver effective soil conservation policy (Pers. Com., FWAG, independent advisor, regional NFU, SWW). More funding would allow greater use of incentives to follow good practice, buy new machinery and invest in the land. It could also allow the recruitment of more project officers. An NFU Policy Analyst added that more government funding is essential, but it needs to be integrated more effectively, and private companies such as supermarkets should also be encouraged to provide funds for regional-scale policy projects.

Defra, however, disagrees that there is a funding problem (Pers. Com., Soils Team). They accept that there could be more funds available to target soils policy, but believe that even with inexhaustible funding the problem of soil monitoring remains. More frequent monitoring would not necessarily be cost-effective or yield representative results, because of the long-term nature of the issue and the variability of soils.

With regard to legislation, it is a commonly held view that financial penalties are necessary to ensure all land managers comply with policy, but that they should only be applied as a last resort. Voluntary initiatives, participation and education are considered at the local level as being the most effective tools in policy implementation. Some stakeholders added that enforcement and prosecution can work against the aims of policy, because farmers are more inclined to openly discuss problems and non-compliance with advisors if there is no concern for penalties. However, even these interviewees agreed that some level of enforcement and penalties are required in the background, if only to guard against repeat offenders, and most

22 Defra news release: Water friendly farming initiative enters new phase: http://www.defra.gov.uk/news/2008/080603b.htm

23 IEEP 2007 and previous IEEP reports

agree that the EA is the body to ensure this enforcement. This balance of agreement also applies at the national level.

It is clear from interviewees in the Axe and Parrett catchment areas that policy drivers with impacts on agricultural soils are not very explicit in their motivation. Soil conservation is seen as largely an indirect effect of policies for water quality (CSF) or of general agricultural/environmental policy, without having its own specific agenda or policy. Soil conservation is promoted as an explicit objective by the advisory organisations on the ground, as it impacts on agricultural practice and production as well as environmental sustainability. Most believe that the same importance should be placed on agricultural soil conservation at the higher policy level.

6.3 Conclusions

Soil conservation policy is designed and implemented at the national level by Defra, considerably influenced by EC legislation. Defra invests heavily in consultation to inform policy design, with the delivery bodies (the EA and NE) and with a wider range of civil society and non-governmental organisations, through the Soil Action Plan Advisory Forum and in invitational consultations such as the draft Soil Strategy for England. Consultation on policy design is judged as important to represent the requirements and considerations of all stakeholders affected by policy, but also because empirical and quantitative monitoring of the state of agricultural soils, and specifically the effect which current policy has had on soils, has yet to produce strong evidence. Current reviews are considering how to strengthen monitoring and identify indicators for policy success, but this process will take time due to the uncertainty and long-term variability of soils and the influence of management practices upon them.

In the Axe and Parrett catchment areas, cross-compliance (CC), agri-environment measures (AEM) and Catchment Sensitive Farming (CSF) are considered the most important policies with regards to agricultural soil conservation. They are seen to complement each other and to provide a structure for engaging and motivating farmers in a way that did not occur under previous policy regimes. Whilst the results on the ground cannot be verified with confidence because of a lack of empirical evidence, there is a sense that policy has moved in the right direction and does take account of local concerns, even if they do not always percolate up to higher levels of policy making where the focus on soil policy, whilst sharper than previously, is still considered subordinate to other concerns. Given a helpful structure, more resources are seen as necessary both at the institutional and farm level to tackle the core issues effectively.

The EA, which has an environmental rather than agricultural focus, is considered the most important authority for implementing soils policy in the catchment areas, mainly due to its role in CSF, which is seen as the most important and effective policy in the catchment areas, but also because of its capacity to enforce standards and apply penalties. The EA complements the more advisory- and incentive- based organisations and has increased farmer focus on soil conservation despite the prominent place of the WFD in its own agenda.

The relatively new CSF approach has been applied to the case study area and has allowed local-level management to achieve results which adhere to national policy whilst reflecting the specific environmental and economic conditions of the area. Stakeholder (civil society and farmer) participation and voluntary interaction are central to this approach, which relies on advice, dedicated project officers, and associated incentives, for its success. It has strong support amongst those interviewed but its main concern is with water, rather than soil, management.

This underlines the general perception that soil conservation needs a higher profile and more institutional support at all levels if it is to be embedded more strongly in both farm practice and agri-environmental policy. Institutional arrangements have been strengthened and the gap between national policy drivers and farm actors reduced by a more participatory approach and more balanced spectrum of policies. This provides a platform on which to build.

7 Policies for soil conservation

7.1 Existing policies and their classification

In the current approach, soil degradation processes and impacts are addressed directly by a few measures within agricultural and environmental policies, and indirectly by a greater number of measures. The policies include mandatory and voluntary mechanisms, and are driven from all levels of the policy spectrum, from European Directives to local-level initiatives. Specifically, Cross-Compliance (CC), agri-environmental measures (AEM) (i.e. Environmental Stewardship (ES)), and the Catchment Sensitive Farming scheme (CSF) have been identified as the key policies addressing soil conservation in England, and specifically in the Axe and Parrett catchment areas. Descriptions of the measures follow below. Table 10 offers a summary of these and other measures, in the classification system developed for the project. The fiches in Section 7.2 elaborate these three key policies in greater detail.

7.1.1 Cross-Compliance

Beneficiaries of the CAP Single Payment Scheme (SPS) need to comply with a range of standards, or in the event of non-compliance, risk a financial penalty in the form of a reduction to the Single Payment. As such, cross-compliance (CC) is a regulatory policy measure.

One set of standards, the ‘Statutory Management Requirements’ (SMR), are derived from nineteen items of EU legislation in the areas of the environment, public health and animal health and welfare. Of these SMRs, those from the Sewage Sludge Directive and the Nitrates Directive are of indirect relevance to soil conservation. Only selected articles from these pieces of legislation are included as cross-compliance SMRs, and are listed in Annex III of Regulation 1782/2003.

Another set of standards, provided for by Annex IV of the same Regulation, establish the framework for Good Agricultural and Environmental Condition (GAEC). This framework directs Member States to introduce standards to address soil erosion, soil structure, soil organic matter and the minimum maintenance of habitats. The GAEC standards are of direct relevance to soil conservation.

Cross-compliance SMR and GAEC standards apply to agricultural land on the holdings of SPS recipients and apply throughout England, including the case study areas. If payments are received for participating in one of eight Axis 2 rural development measures, cross-compliance SMR and GAEC standards extend across the whole holding.

Of the GAEC standards implemented in England, several are of significance for soil policy. In particular, there is an obligation on farmers to complete a Soil Protection Review (SPR), a plan identifying soil characteristics and remedial measures on a farm-by-farm basis. The SPR is a flexible approach to identifying soil problems on the farm, and is intended to stimulate the development of targeted measures capable of addressing specific problems. Given the horizontal and baseline character of cross-compliance, the focus on measures tailored to the individual farm is positive.

Three other relevant cross-compliance measures, adopted throughout England in January 2005 to better protect agricultural soils, focussing on erosion, soil structure and soil organic matter decline, are concerned with:

- Post-harvest management of land
  - Following harvest, one or more of five measures must be implemented in order to reduce soil erosion and runoff. These measures are:
    - The stubble of the harvested crop is to remain in the land.
    - The land is sown with a temporary cover crop. If this is grazed out or cultivated during the autumn or winter, a rough surface must be left as soon as conditions permit.
    - The land is sown with another crop, and in normal weather within ten days of a final seedbed preparation. (This requirement does not restrict cultivation sequences to create stale seedbeds.)
    - The land is under cultivation sequences used to create stale seedbeds.
    - The land is left after harvest with a rough surface to encourage the infiltration of rain. This would normally be achieved by operations such as ploughing, discing or tine cultivation. (This standard also requires leaving a rough surface after fumigant use in the autumn.).
- Waterlogged soil
  - Mechanical field operations and the use of a motorised vehicle is not permitted on waterlogged soil in order to maintain soil structure and prevent compaction. Six exceptions apply.
- Crop residue burning restrictions
  - Crop residues such as cereal straw cannot be burned. This is in order to maintain soil organic matter (and also to prevent damage to landscape features). Three exceptions apply.

A fifth measure is concerned with preventing overgrazing and unsuitable supplementary feeding. In addition, the rules concerning the maintenance of permanent pasture are indirectly relevant to soil conservation. If the area of permanent pasture in England declines by 5 % when compared with 2003 figures, steps will be taken to prevent any further loss of permanent pasture. The inclusion of Environmental Impact Assessment legislation under GAEC is intended to prevent the loss of ecologically valuable pasture into other uses.

7.1.2 Agri-Environment Measures (AEMs)

Agri-environment measures in England are designed at the national level. At present, the main national measure is Environmental Stewardship (ES) (see Figures 9 and 11 in the Annex). ES is an incentive measure, comprising three schemes; Entry Level Stewardship (ELS) (national level; open to all; no advice; simple management); Organic Entry Level Stewardship (OELS) (as per ELS but for organic farmers); and, Higher Level Stewardship (HLS) (regional level; competitive; discretionary; targeted management; assistance for capital works). Farmers choose from a menu of options to implement, and receive payments upon meeting targets prescribed by these options. ES is complimentary to CC, and should only pay for agricultural practices that go beyond the relevant mandatory requirements and GAEC standards (baseline).

Soil conservation traditionally has not been a primary objective of AEMs in England. However measures for the protection of soils were introduced for the first time under Environmental Stewardship (ES) in 2005. Measures of direct relevance to soil conservation within ELS are; management of high erosion risk cultivated land; management of maize crops to reduce soil erosion; the installation of buffer strips and field margins; and the

installation of beetle banks. In HLS, the further options are; arable reversion to unfertilised grassland; arable reversion to grassland with low fertiliser input; the creation of in-field grass areas to prevent erosion or runoff; preventing erosion or runoff from intensively managed improved grassland; seasonal livestock removal on grassland with no input restriction; and, nil fertiliser supplement.

All applicants have to prepare a Farm Environmental Record, which identifies key issues. As part of this, farmers are obliged to identify fields where water or wind erosion or runoff occur or may occur in the future. In the past, farmers could then decide to draw up a Soil Management Plan. Although this has now been withdrawn as an option under ELS, existing agreements are still in operation (see Section 6.2.3). The Soil Management Plan determined the risk of water erosion and runoff on a field by field basis, from which a risk map was drawn up. The map is intended to guide farmers on where best to place ELS/OELS management options open to them under these voluntary schemes.

7.1.3 Catchment Sensitive Farming

Catchment Sensitive Farming (CSF) applies only to agriculture in England and was introduced to address diffuse water pollution issues, including poor soil management, and particularly sedimentation. The purpose is to encourage early voluntary action by farmers to reduce diffuse water pollution and so contribute to meeting a number of UK policy objectives, including implementation of the Water Framework Directive (WFD). The main emphasis is on information, advice and improved awareness of the issues in a series of different priority catchments covering about forty per cent of the farmed area in England. There is also an investment aid scheme, known as a capital grants scheme in England, in place for a limited period. CSF measures contain strong links to the resource protection measures in ES.

Originally introduced in April 2006 the measure initially ran to March 2008, however it has recently (June 2008) been extended for at least three years to March 2011, with the possibility of a further extension to 2015[24].

[24] CSF report / website

Table 10: Classification of policy measures in the Axe and Parrett catchments, Devon and Somerset, United Kingdom

Type of Policy Mechanism/ Mode of governance	**Practical classification** **Nature of the Policy Objective**			**Policy relationship to agriculture**	**Geographical level**	**Analytical classification – Channels of Impact** Please note that policy measures may lead to more than one change, if so please specify Primary (1) and Secondary (2) impacts – secondary impacts will be the consequence of the primary impacts e.g. to support their delivery or resulting from the changes they bring about. Y = Yes, N = No		
	Soil conservation is the **primary objective** of a policy measure	Soil conservation is the **secondary objective** of a policy measure	Soil conservation is a **By-product**	Agricultural (AG) or non Agricultural (NAG) focused policy	European (E), national (N), regional (R) or local (L) measure, and policy reference	Developing new/altering existing rules (institutions)	Developing and/or altering governance structures/ implementation approaches	Directly impacting on farmer behaviour/ decision making/ factor allocation and management practices
Command and Control			Nitrate Vulnerable Areas ie bans on use of Nitrates in certain areas	NAG	E - Nitrates Directive (91/676/EC).	Y – Setting up of new rules to require identification and implementation of NVZs (1)	Y – development of governance structures to support NVZ allocation (2)	Y – bans use of fertilisers in certain areas (2)
			Water Body Management	NAG	E – Water Framework Directive (2000/60/EC). Transposed into N in 2003	Y	Y	Y
Incentive based measures/economic instruments		Agri environmental measures requiring good farming practice and specifying soil protection		AG	E but varies at N		Y – development of payment agencies to deliver payments (2)	Y – Payments for conducting certain action (1)
		Cross-compliance ie funding linked to SFP requiring good farming practice among which soil protection		AG	E but varies at N			Y

Case study United Kingdom

Type of Policy Mechanism/ Mode of governance	Practical classification Nature of the Policy Objective			Policy relationship to agriculture	Geographical level	Analytical classification – Channels of Impact Please note that policy measures may lead to more than one change, if so please specify Primary (1) and Secondary (2) impacts – secondary impacts will be the consequence of the primary impacts e.g. to support their delivery or resulting from the changes they bring about. Y = Yes, N = No		
	Soil conservation is the **primary objective** of a policy measure	Soil conservation is the **secondary objective** of a policy measure	Soil conservation is a **By-product**	Agricultural (AG) or non Agricultural (NAG) focused policy	European (E), national (N), regional (R) or local (L) measure, and policy reference	Developing new/altering existing rules (institutions)	Developing and/or altering governance structures/ implementation approaches	Directly impacting on farmer behaviour/ decision making/ factor allocation and management practices
Moral Suasion Initiatives ie it has a normative dimension that farmers should protect soils		Organic farming		AG	N			Y
	Catchment Management schemes			AG	L		Y – developed activist groups of farmers and cooperatives (2)	Y (1)
Information and capacity building measures, i.e. guidance, advisory measures and farmer support initiatives	Soil Action Plan			NAG	R		Y	
		FWAG support network		AG	N but acting at L		Y	

7.2 Description, analysis, and evaluation of policy measures

7.2.1 Fiche 1: Cross-compliance

<table>
<tr><th colspan="3">Part A: Summary of Measure</th></tr>
<tr><td>Formal title of measure and date of implement-tation</td><td colspan="2">Cross-compliance GAEC Standards, implemented on 1 January 2005.
As provided for by Council Regulation 1782/2003 (OJ L 270, 21.10.2003), Article 5, ‘Good agricultural and environmental condition’.[25]
England Statutory Instrument Number: 2005 No. 918</td></tr>
<tr><td>Short description of the measure</td><td colspan="2">Cross-compliance standards comprise two sets.
One set of standards is collectively referred to as ‘Statutory Management Requirements’ (SMR). These are derived from 19 items of EU legislation in the areas of the environment, public health and animal health and welfare. Of these from the Sewage Sludge Directive and the Nitrates Directive are of indirect relevance to soil conservation.
The other set of standards, provided by Annex IV of the same Regulation, set the framework for Good Agricultural and Environmental Condition (GAEC). This framework directs Member States to introduce standards to address soil erosion, soil structure, soil organic matter and minimum level of maintenance of habitats. The GAEC standards are of direct relevance to soil conservation and are the focus of this fiche.
Cross-compliance SMR and GAEC standards apply to agricultural land on the holding in the context of SPS direct payments. If payments are received for participating in one of eight Axis 2 rural development measures, cross-compliance SMR and GAEC standards extend across the whole holding.</td></tr>
<tr><td>Type of policy measure</td><td colspan="2">Cross-compliance is a regulatory policy measure, focused specifically at the agricultural sector. Standards are implemented at the country level (i.e. England), and apply to all beneficiaries of the SPS.</td></tr>
<tr><td rowspan="2">Objective of policy measure and relevance</td><td colspan="2">Annex IV of the Regulation sets out the framework for defining minimum requirements for GAEC. Three ‘issues’ and six ‘standards’ are set out for soils. In addition, four ‘standards’ which could potentially have implications for soil management (e.g. through management of green cover) are set out in relation to minimum level of maintenance of habitats.</td></tr>
<tr><td>Issue
Soil erosion: protect soil through appropriate measures
Soil organic matter: maintain soil organic matter levels through appropriate practices
Soil structure: maintain soil structure through appropriate measures.</td><td>Standard
- Minimum soil cover
- Minimum land management reflecting site specific conditions.
- Retain terraces
- Standards for crop rotation where applicable.
- Arable stubble management.</td></tr>
</table>

[25] As part of the CAP Health Check the Commission has published legislative proposals (COM(2008) 306/4) which, if adopted, would replace Council Regulation 1782/2003 with a Regulation ‘establishing common rules for direct support schemes for farmers under the common agricultural policy and establishing certain support schemes for farmers’. As the legislative proposals currently stand, the new Regulation would make a number of amendments to GAEC (now Article 6 and Annex III).

	Minimum level of maintenance: ensure a minimum level of maintenance and avoid the deterioration of habitats	- Appropriate machinery use. - Minimum livestock stocking rates or/and appropriate regimes - Protection of permanent pasture - Retention of landscape features - Avoiding the encroachment of unwanted vegetation on agricultural land
	In England, GAEC standards have been introduced for each of the above issues (see section on Technical Measures, below).	
	How relevant are the objectives of the measure to the soil degradation threats in your region? ☐ ☐ ☐ ☐ ■ Not very Very	
Indirect effects	Good soil management is essential to maintaining agricultural productivity and thus in the interest of all farmers. Of the SMR, those from the Sewage Sludge Directive and the Nitrates Directive are of indirect relevance to soil conservation. Standards for crop rotation and arable stubble management may also provide benefits to plants, farmland birds, and other mammals and invertebrates found in arable systems.	
Linkages to other policy measures	GAEC standards form the baseline level of sustainable land management. Agri-environment schemes, as provided for by Regulation 1698/2005, must include more demanding standards and not duplicate GAEC standards. If payments are received for participating in one of eight Axis 2 rural development measures, cross-compliance extends across the whole holding. If only a direct payment is received under the SPS or SAPS, then GAEC standards only apply to agricultural land.	
Funding	There is no additional funding available to farmers and land managers for complying with GAEC. The level of payment received under the Single Payment is not connected in any way to the costs involved in meeting GAEC. They are baseline standards that mostly consist of legal requirements and hence there is no justification for providing additional funding to beneficiaries of the SPS. The cost of providing information to farmers and enforcement and control is borne by the SPS delivery agency, the Rural Payments Agency.	
Summary of assessment and conclusions	GAEC provides a suitable framework for introducing soil conservation measures and provides Member States with a degree of flexibility in order to implement nationally or regionally adapted measures. The GAEC standards in England appear suitable to responding to the four issues included in the Annex IV framework, and the SPR in particular is likely to be effective, assuming its implementation at farm level improves both awareness and management practices in relation to soil management. The SPR requires farmers to identify areas at potential risk of soil damage on their holding and then to choose appropriate management options to address these risks.	

	A similar management option to the SPR, the Soil Management Plan (SMP)[26], was removed from the ELS agri-environment scheme on 1 January 2007 as a result of concerns from the Commission that the requirements of the SMP were too close to those of the SPR (i.e. the cross-compliance baseline for receipt of Pillar 1 and Pillar 2 payments) and as a result payments for the SMP could not be justified[27]. Questions surround the appropriate division between cross-compliance and agri-environment, and thus the extent to which Pillar 1 payments should be 'greened' to provide relatively basic environmental benefits, given that cross-compliance does not provide the underlying rationale for direct payments and the need to use a limited rural development budget to respond to a range of environmental challenges. The rules preventing the ploughing up of permanent pasture could potentially be beneficial to soil conservation in the event that significant losses (5-10 per cent) of permanent pasture occur; for example, in response to high arable commodity prices. However, the rules do not prevent permanent pasture from being ploughed up unless the pasture in question is of significant ecological interest (as determined under the EIA Regulations). In principle, it should not be possible to plough up pasture at high risk of soil erosion as identified under the SPR; for example, if the pasture is located on a steep slope and/or runoff is likely to enter a watercourse. Overall, the cross-compliance GAEC standards in England should ensure a minimum level of suitable soil management takes place, given the potential for intensification of agricultural practices to occur in response to market conditions and in the context of decoupled direct payments. In practice, a lot will depend on the quality of SPRs undertaken at farm level and the extent to which implementation of appropriate management practices occur, where necessary.
Recommen-dation	The measure should be maintained but improved. Monitoring data for soils within cross-compliance measures is currently considered inadequate (IEEP, 2007; stakeholder interviews), although research on indicators for soil attributes and approaches to modelling soil erosion risk are being developed in England. This data should be used to review the current standards' effectiveness, and inform improvements to better target soil degradation processes in England. There are, however, concerns within the Defra Sustainable Farm Management Team that the Commission consider that England already has significant cross-compliance standards installed, and that the Commission will intervene to resist the installation of further English standards should improvements be recommended, in order to 'keep a level playing field with other Member States' (Pers. Com., Defra). The success of the permanent pasture rules in limiting the creation of new arable land also need to be closely monitored and subject to review.

26 http://www.defra.gov.uk/erdp/schemes/es/soilmanagementplan.htm

27 http://www.defra.gov.uk/rural/rdpe/pdf/RDPQA.pdf

Part B: Detail on the Measure's Design, Implementation, Enforcement and Impacts	
Policy design	In England, the Ministry concerned with agriculture and the environment, Defra, established a working group for developing GAEC standards and consulted a range of experts from relevant government and non-government organisations, including farming agencies. A public consultation was also completed.
Policy implementtation I: Implementation at administrative level	The Rural Payments Agency (RPA) is responsible for controls and applying payment reductions in its role as the Paying Agency. Defra has been involved in setting up the system of cross-compliance controls and payment reductions along with the RPA. The RPA is the Competent Control Authority for all GAEC standards.
Policy implementation II: Method of delivery to farmers	Defra has produced a range of written literature, in consultation with stakeholders, explaining farmers' obligations under cross-compliance and this includes a handbook which is updated annually and sent to all farmers receiving the Single Payment. In 2006 a publications entitled 'Single Payment Scheme Cross-compliance - Guidance for Soil Management' and 'Single Payment Scheme - Cross-compliance Soil Protection Review' were produced[28]. Defra has also contracted a private company, Momenta, to lead a consortium, which gives advice to farmers on all aspects of cross-compliance through meetings, farm walks, a telephone helpline and the internet[29]. All publications on cross-compliance are also available from the RPA website[30]. These advisory activities are funded through national resources.
Targeting	The SPR offers a flexible approach to identifying soil problems on farm, and allows individual farmers to develop targeted measures capable of addressing specific problems taking into account local circumstances. Given the horizontal and baseline character of cross-compliance, the ability to design measures on a farm by farm basis is positive. Other GAEC standards are more prescriptive in nature.
	To what extent does the implementing body have flexibility in the targeting of the policy measure so that it is adapted to local conditions? ☐ ☐ ☐ ■ ☐ Low High
What Drives Uptake?	The key driver for compliance with GAEC and SMR standards is the potential reduction to the Single Payment if non-compliance is identified as part of an on-the-spot control. In the case of GAEC standards based on national legalisation, then all landowners have a legal obligation to comply with the standards, regardless of whether they are in receipt of the Single Payment or not.

[28] http://www.defra.gov.uk/Environment/land/soil/information/publications.htm#spsprotreview

[29] http://www.crosscompliance.org.uk

[30] http://www.rpa.gov.uk

	For example, the burning of crop residues has been illegal since 1993 and is a legislative requirement that would exist in the absence of cross-compliance.
	■ Obligation □ Financial incentive □ Information & support □ Exhortation □ Other
Technical measures	There are four GAEC standards in England that are directly relevant to soil conservation: - Soil Protection Review (SPR) A SPR must be completed and updated once per year by all farmers in receipt of the Single Payment[31]. In 2006 the SPR required farmers to undertake a simple risk assessment in relation to soil structure and organic matter, and to prevent erosion. Remedial measures identified as part of the SPR had to be implemented from 1 January 2007. The SPR must then be updated annually in response to circumstances (i.e. in the event that remedial measures are not effective or farm management systems or cropping practices change. A copy of the SPR must be kept available for inspection. - Post-harvest management of land Following harvest, one of five measures must be implemented in order to reduce soil erosion and runoff. These measures include retaining stubble and sowing a temporary cover crop. - Waterlogged soil Mechanical field operations and use of a motorised vehicle are not permitted on waterlogged soil in order to maintain soil structure and prevent compaction. Six exceptions apply. - Crop residue burning restrictions Crop residues such as cereal straw cannot be burned in order to maintain soil organic matter (and also to prevent damage to landscape features). Three exceptions apply. Two GAEC standards in England are indirectly relevant to soil conservation: - Overgrazing and unsuitable supplementary feeding. Natural and semi-natural vegetation cannot be overgrazed and unsuitable supplementary feeding of livestock cannot be carried out in order to protect important habitats. As a by-product, this standard should be beneficial in reducing soil erosion and poaching. - Protection of hedgerows and watercourses. No cultivation with 2 metres of the centre of a hedge, watercourse or field ditch or 1 metre from the edge of watercourse or field ditch. The standard, which is primarily aimed at reducing diffuse pollution, requires farmers to take all reasonable steps to maintain a green cover on land within the buffer protection strips specified above.

[31] It is not clear whether the small number of land owners in receipt of Pillar 2 funds, such as agri-environment or LFA payments, but not in receipt of the Single Payment have to undertake an SPR. http://www.defra.gov.uk/erdp/schemes/es/soilmanagementplan.htm

	The permanent pasture rules are also relevant to soil conservation. If the area of permanent pasture in England declines by 5 % when compared with 2003 figures, steps will be taken to prevent any further loss of permanent pasture. The inclusion of Environmental Impact Assessment legislation under GAEC is intended to prevent the loss of ecologically valuable pasture into other uses.
Enforcement and control	On-the-spot controls for all cross-compliance standards are conducted by up to three different Competent Control Authorities in England. The RPA is responsible for GAEC inspections. At least one per cent of farm businesses submitting claims under the Single Payment Scheme are inspected each year (Pers. Com., RPA). Of this total, twenty per cent are selected at random and the remainder according to a risk assessment process. During the inspection the SPR is checked to see if it has been completed, if it identifies problems and measures to address them, if the identified measures have been implemented, if the annual review has been completed and if there is compliance with any specific guidance. Compliance with the other soil standards is checked through a full physical inspection of all agricultural land parcels. In 2007, there were 35 breaches of the SPR, which had not been completed in most cases[32]. A 3 % penalty to the SP was applied in most cases. With the exception of the GAEC standard for protection of hedgerows and watercourses (35 breaches), there were zero breaches of the other relevant GAEC standards (i.e. post harvest management, waterlogged soil, crop residue burning and overgrazing/unsuitable supplementary feeding). The RPA employs 200 inspectors who are involved in conducting Single Payment Scheme and cross-compliance inspections as well as other CAP scheme inspections. The average time taken for a full inspection by the RPA is about 36 hours with arable farms taking less time to inspect than livestock farms (due to the lengthy checks required for the animal identification SMR). The inspection regime appears to provide farmers with the motivation to comply, although it is clear that compliance with standards that require some form of record keeping are easier to check than those that rely solely on visual inspection. Higher arable commodity prices may drive the loss of permanent pasture, although according to a 2007 evaluation the level of permanent pasture had not declined against the reference level in England.
Monitoring and evaluation	The environmental impacts arising since the 2003 reform of the CAP, including those attributable to cross-compliance, are being monitored by two independent research organisations (CCRI and CSL) as part of the Defra CAP observatory programme. Monitoring data for soils is currently considered inadequate although research on indicators for soil attributes and approaches to modelling soil erosion risk are being developed in England. Farmers' understanding of cross-compliance is monitored through an annual survey, conducted by Momenta for Defra.
Outcomes of policy measure	Evaluation work suggests that cross-compliance has increased awareness amongst farmers of soil management issues and related cross-compliance obligations, as well as the environmental reasons for introducing them.

[32] http://www.rpa.gov.uk/rpa/index.nsf/UIMenu/24BCC198835C488D80257433002D3D7E?Opendocument

	However, due to the time lag between policy implementation and observable environmental outcomes, it is not yet possible to state with any certainty what the environmental impact has been33. These may be expected to be positive (but relatively modest in comparison to other measures such as agri-environment schemes) given the high rate of compliance.
Analysis of drivers of policy measures' outcomes	The outcomes have been achieved through the combination of the introduction of new requirements on farmers and a new governance structure that acts to inform farmers of the requirements and to penalise them in the event of non-compliance.
Part C – Evaluation of the Policy Measure	
Effectiveness of policy measure (in relation to the extent to which objectives are achieved, and cost-effectiveness)	According to a range of stakeholders and experts (e.g. Pers. Coms. with Defra, FWAG, NFU) the GAEC standards in England should be capable of providing an effective baseline for minimum levels of soil management. The SPR, in particular, is considered to have significant potential to deliver soil management improvements since farmers are supposed to choose appropriate management options suited to local conditions and update these to reflect changing circumstances. The SPR is an example of 'added value' from cross-compliance since it is an entirely new requirement. This means farmers receiving a direct payment in England have an additional requirement to follow. It is unclear whether sufficient monitoring of the conversion of permanent pasture to arable land is taking place, particularly in the context of rising cereal prices. The creation of new arable land could negatively impact on soil organic matter, soil structure and potentially result in an increase in soil erosion. Reliable analysis of the effectiveness of CC needs to be informed by empirical evidence from monitoring the outcomes of the measures' implementation. Such data and information are not available at present but Defra recognise this requirement and are taking steps to identify indicators for effective monitoring, and performing a review of the SPR.
Constraints to achieving full potential of the policy measure	Some farmers appear to be unaware of the need to complete a SPR. In addition, there is a potential for farmers to not complete it adequately, to not identify the most appropriate management options or to fail to implement it. Inability to monitor conversion of permanent pasture to arable land may hinder attainment of soil conservation objectives. Deficiency of empirical monitoring data.
Reasons for the success of the policy measure (where appropriate)	

33 In some cases there may be inherent difficulties in attributing environmental outcomes to specific GAEC standards given the range of local soil conditions as well as other influencing factors and data requirements.

7.2.2 Fiche 2: Agri-environment Measures - England

Part A: Summary of Measure	
Formal title of measure and date of implementation	Agri-Environment payments (Article 39 of Council Regulation (EC) No 1698/2005) Agri-environment schemes were first introduced in England in 1985. A number of **Environmentally Sensitive Areas** (ESAs) were introduced in 1987, increasing in number to twenty-two by 1994. **Countryside Stewardship** was brought in as a pilot scheme in 1991 and mainstreamed in 1996. In 2005, the ESA and CS schemes closed to new applicants (although many existing agreements are still in operation) and a new agri-environment scheme was introduced, **Environmental Stewardship** (ES), which comprises Entry Level Stewardship (ELS), Organic Entry Level Stewardship (OELS) and Higher Level Stewardship (HLS). ES was transposed into national legislation by Statutory Instrument 2005/621. From 2007 the statutory basis for all new agreements is section 7 of the Natural Environment and Rural Communities Act 2006 (excluding section 7(3)).
Short description of the measure	The rationale for the agri-environment measure (as set out in the preamble to Council Regulation 1698/2005 – paragraph 35) is to 'further encourage farmers and other land managers to serve society as a whole by introducing or continuing to apply agricultural production methods compatible with the protection and improvement of the environment, the landscape and its features, natural resources, ***the soil*** and genetic diversity'. It should only pay for management that goes beyond the relevant mandatory standards (for example cross-compliance requirements (SMR and GAEC) and other environmental legislation). The protection of natural resources and soil has been an aim of the agri-environment measure at an EU level since 1992. Previous to this the main focus of the agri-environment measure had been to target areas of biodiversity and landscape value. In England, however, measures for the protection of natural resources, including soils, were introduced for the first time under Environmental Stewardship in 2005. Prior to this the focus of agri-environment schemes in England had been on the maintenance and enhancement of biodiversity, landscape, the historic environment and the provision of access.
Type of policy measure	Environmental Stewardship is an incentive measure, focused at the agricultural sector. ELS and OELS are implemented at the country level (i.e. England), and HLS is operated at a regional level. ELS and OELS are open to all farmers. They receive a flat rate payment of £30/ha for all eligible land on the farm, and for this they have to sign up to a range of management options. Each option is allocated a certain number of points, and applicants must meet a target number of points for all management options combined (this target equates to 30 points x hectares of eligible land). Applicants can choose which options they wish to use from a menu/list. HLS is a discretionary scheme, whereby farmers compete for a limited pot of money. Local targets are set (at the Joint Character Area level) and applicants must first carry out a Farm Environment Plan, setting out the environmental priorities for their holding. Local targets are set out for each Joint Character Area and applications must demonstrate how their

	agreement will meet these local priorities. Payment rates are identified for each management option at a national level.
Objective of policy measure and relevance	Environmental Stewardship provides funding to farmers and other land managers in England who deliver effective environmental management on their land. It has four primary objectives, which are to: • conserve wildlife (biodiversity) • maintain and enhance landscape quality and character • protect the historic environment and natural resources; and, • promote public access and understanding of the countryside. It also has two secondary objectives: • Genetic conservation; and, • Flood management The main focus of the resource protection objective is to improve water quality and reduce soil erosion. The scheme has 3 elements: • ELS (open to all; no advice; simple management); • OELS (as per ELS but for organic farmers); and, • HLS (competitive; discretionary; targeted management; capital works)
	How relevant are the objectives of the measure to the soil degradation processes in your region? ☐ ☐ ■ ☐ ☐ Not very Very Particularly in relation to ELS, the measures could be more targeted to specific circumstances – the relevant soils measures are not always being taken up in areas of risk. In the Axe and Parrett catchment areas, CSF is considered a more targeted and prescriptive approach to the degradation processes of the region, and includes additional advice provision. However, uptake levels for ES are good as there are numerous options available. The technical measures and advice provision within CSF are designed to align with, and deliver, ES measures, both to assist those farmers involved in both schemes, and to ensure consistency of management practice across regions / catchments, which can potentially target ES approaches more appropriately, and with greater focus on soils.
Indirect effects	Even direct effects are difficult to establish currently, but soil measures are all also intended to benefit water quality, and some, such as buffer strips, are also introduced to benefit biodiversity.
Linkages to other policy measures	Key drivers and targets in relation to soil quality in England include: Natural Environment (PSA 28) 'Secure a healthy natural environment for today and the future'. Water quality and Land management (i.e the contribution of agricultural land management to the natural environment as measured by the positive and negative impacts of farming) are two of the indicators for measuring progress. Climate Change PSA 'Lead the global effort to avoid dangerous climate change'

	There is a commitment within the Sustainable Food and Farming Strategy to halt organic matter decline by 2025 Other instruments include: **Cross-compliance** (see CC fiche for more details) – GAEC requires measures to be introduced to address soil erosion, protect organic matter and soil structure. These are implemented in England through GAEC 1 -4. In addition the cross-compliance permanent pasture rules will limit the amount of permanent grassland that can be converted to arable. The Soil Management Plan (SMP) was formerly an option within ELS, but its continued inclusion was rejected on 1 January 2007 as a result of concerns from the Commission that the requirements of the SMP were too close to those of the SPR (i.e. the CC baseline for receipt of Pillar 1 and Pillar 2 payments) and as a result payments for the SMP could not be justified[34]. Questions surround the appropriate division between cross-compliance and agri-environment, and thus the extent to which Pillar 1 payments should be 'greened' to provide relatively basic environmental benefits, given that cross-compliance does not provide the underlying rationale for direct payments and the need to use a limited rural development budget to respond to a range of environmental challenges. **EIA** (Agriculture) Regulations – will limit the amount of permanent grassland that can be converted to arable **ECSFDI** – provides advice and grants for small capital items in 40 priority catchments (see CSF fiche for more details). Natural England deliver both AEM schemes and the CSF scheme in its priority catchments in England, and therefore measures within both sets of schemes can be synchronised. ES, particularly ELS, is seen as a key means of the delivery of CSF benefits.
Funding	ES is part of the Rural Development Programme for England, which is funded through the EAFRD, with national co-financing. England also applies additional levels of voluntary modulation, 80 % of which is co-financed and allocated to ES within Axis 2. The total funds allocated to ES in the 2007-2013 programming period is £2.9 billion. Is funding sufficient? Calculations undertaken by Natural England in 2006 indicated that approximately £500 million/year was needed to meet the identified biodiversity, **resource protection**, landscape and historic environment needs at current payment rates. This is less than is available, currently, even with high levels of voluntary modulation. From the publicly available information it is not possible to separate out the budget needed for soil protection. In terms of the biodiversity objective, it has been estimated that £430 million/year is needed to meet the English proportion of the UK Biodiversity Action Plan[35] targets and that ELS would be needed for £324 million of this[36]. ES is part of the Rural Development Programme for England, which is funded through the EAFRD, with national co-financing.

[34] http://www.defra.gov.uk/rural/rdpe/pdf/RDPQA.pdf

[35] GHK, 2006, Costs of Delivering the UK BAP, Report to Defra

[36] RSPB, 2006, Analysis of Agri-environment delivery for UK BAP

	England also applies additional levels of voluntary modulation, 80 % of which is co-financed and allocated to ES within Axis 2. The total funds allocated to ES in the 2007-2013 programming period is £2.9 billion. Is funding sufficient? Calculations undertaken by Natural England in 2006 indicated that approximately £500 million/year was needed to meet the identified biodiversity, **resource protection**, landscape and historic environment needs at current payment rates. This is less than is available, currently, even with high levels of voluntary modulation. From the publicly available information it is not possible to separate out the budget needed for soil protection. In terms of the biodiversity objective, it has been estimated that £430 million/year is needed to meet the English proportion of the UK Biodiversity Action Plan[37] targets and that ELS would be needed for £324 million of this[38]. The current Health Check proposals, as they currently stand, are unlikely to result in an increase in the budget for ES in England as any increase in compulsory Modulation (CM) has to be met with a concomitant reduction in Voluntary Modulation (VM). This will mean that there are unlikely to be any additional funds to address the 'new challenges' – effective soil protection measures have implications for water quality.
Summary of assessment and conclusions	The inclusion of resource protection measures within ES has been important, not just in terms of the environmental benefits provided, but also in terms of increasing farmers' awareness of resource protection issues and ways of managing their soils, etc. sustainably. Advisory input is critical to this. Resource protection is likely to stay as an objective of ES in the medium term, although the nature of the options within the scheme may change as the regulatory baseline changes and/or as cross-compliance develops. Although there appears to be a good correlation between uptake of resource protection measures and areas at risk from diffuse pollution there remains a need to ensure that ELS in particular is better targeted at meeting local environmental priorities.
Recommen-dation	Agri-Environment support for maintaining healthy soils, reducing erosion and runoff should be maintained in England, but measures need to only reward actions that go beyond those required by regulation, including cross-compliance. The recent Review of Progress (ESRoP) shows that improvements are needed across all elements of Environmental Stewardship, including for resource protection in order to ensure it provides improved value for public money. Some of the key findings of the review included the need to improve the effectiveness of ES options; to get better cross-sectoral uptake of the scheme; and to ensure that there is a better fit of options chosen under ELS with the environmental priorities of the area. With the recent removal of the Soil Management Plan from ELS, work is ongoing between the Environment Agency (EA) and Defra to look at ways of retaining some of the benefits of the plan, but delivered in a more focused way. The focus needs to start with a consideration of the problems and risks and then plan how to manage these. This way of thinking needs to be incorporated into changes to agri-environmental options.

[37] GHK, 2006, Costs of Delivering the UK BAP, Report to Defra

[38] RSPB, 2006, Analysis of Agri-environment delivery for UK BAP

	Estimates from a number of sources suggest that additional funds are needed for ES in order for it to deliver fully against its objectives; however no estimates are available specifically for resource protection measures. As set out in Section C below, a number of changes to ES have been proposed as a result of the ESRoP. Those relating specifically to resource protection measures, and relevant to soil protection, include: - **New/revised options** including: a) capital item/option for protection against wind erosion; b) new options and capital items for tramline management, and enhanced ditch management to buffer pollutants; c) new options for wider grass buffer strips (12m); d) a possible new cover crops option; and e) enhanced maize management. - Consideration of a **revised management plan approach** which would deliver benefits above baseline requirements - **Removal of existing options** including those for the management of high erosion risk cultivated land and management of brassica fodder crops followed by over-wintered stubbles – these would become cross-compliance requirements. - **Improve targeting** for resource protection options Develop an enhanced programme of **advice** to support ELS delivery – estimates are that this would cost between £3-6 million/year – but sources for this funding would need to be found.
Part B: Detail on the Measures Design, Implementation, Enforcement and Impacts	
Policy design	Defra has overall responsibility for ES in England, with Natural England responsible for delivery (since October 2006 – prior to this Defra was responsible for delivery through its delivery body the Rural Delivery Service (RDS)). The development of ES was an inclusive process led by Defra in close consultation with its statutory agencies, farming organisations and relevant environmental NGOs. The process was overseen by the Agri-Environment Steering Group and smaller working groups were set up to develop particular elements of the scheme – all these groups included key stakeholders. A number of full public consultations were also carried out. A Review of Progress of ES has just been completed (May 08). This was led jointly by Defra/Natural England but included 4 national stakeholder events. The topic specific working groups also included key stakeholders on them.
Policy imple-menttation I: Implementation at administra-tive level	Implementation of ES is the responsibility of Natural England, Defra's statutory agency for the natural environment. ELS is managed nationally and HLS managed at a regional level, with budgets devolved to the region. ELS is a self-certifying scheme and entry is automatic if sufficient points are attained. For HLS, each region has a team of officers responsible for HLS delivery. Assessment panels, led by Natural England but including representatives from the other statutory agencies (specifically EA and EH), meet quarterly to determine which applications are to be successful. There is a frustration from some quarters that, in order to meet the SSSI target, it is perceived that higher priority is given to HLS applications that

	are within SSSIs rather than those meeting the broader objectives of the scheme, including resource protection.
Policy implementation II: Method of delivery to farmers	**ELS:** Administered by Natural England via streamlined application process. Options are focused on 'simple but effective' management. No co-funding required from applicants. On-line applications are also possible. This is a new approach introduced in 2005. No 1:1 advice, but workshops/group advice plus leaflets and information are provided via NE's Conservation Advice Programme, delivered by ADAS and FWAG with a budget of approx. £1.2 million/year. In order to be eligible for ELS, the applicant's land must be registered on the Rural Land Register. Applicants are required to fill in a Farm Environment Record (FER) which identifies key features on the farm (it is a condition of the scheme that these features are identified, mapped and then retained) and areas at risk of soil-erosion and runoff (if such areas are identified, the handbook recommends that relevant options are chosen). The applicant will have been given a points target for their holding (number of hectares x 30) and has to choose sufficient options to meet this points target and set these out in the application form. Currently he/she has a free choice from a menu of over 50 options (but note that the ESRoP has recommended changes to this). These need to be marked on an 'options map'. The application, including relevant declarations, is sent to Natural England for processing and if all forms are correctly filled in, an agreement will be issued. **HLS:** Highly targeted, discretionary scheme. Management options are focused on maintenance, enhancement and restoration of features and habitats. Capital works are included within HLS. No co-funding required from applicants. Applicants to HLS normally have to either already have an ELS agreement or be entering ELS at the same time, as ELS is designed to underpin HLS. Farmers are required to fill in a Farm Environment Plan, setting out the key environmental issues/features on the farm and the priorities for management. Depending on whether these fit with the local targets for the scheme then applicants are advised on whether it is worth making an application. Applications are generally made with the help of specialist advisers which can come from a range of organisations – FWAG, RSPB, Wildlife Trusts, etc. Farmers can choose from a range of options, but those chosen should be focused on features identified within the FEP. Each option has some prescriptions associated with it and an Indicator of Success – this identifies the outcome that should be aimed for. Once a set of options have been chosen, these are developed into an application, which is submitted to Natural England and assessed on a quarterly basis in relation to the environmental targets and the available budget.
Targeting	**ELS:** Open to all who are able to meet the points threshold. Guidance sheets on the most appropriate options for each Joint Character Area are sent out with all application forms, but farmers are not obliged to consider these.[39]

[39] The ES RoP has put forward proposals to make the scheme more 'geographically literate', by producing regional lists of options and by introducing 'split lists' (i.e. one for boundary features, one for in-field features) whereby farmers would be required to choose a certain number of options from each list. However these have not been taken forward yet.

	HLS: Highly targeted. A targeting statement is produced for each Joint Character Area setting out the environmental priorities for that area (primary and secondary priorities). Applications are scored against these. Natural England is in the process of developing a spatial approach to HLS targeting which will map the key priority areas in relation to the 5 primary objectives of the scheme. The aim is to produce a multi-objective map to allow local advisers to plan where agreements should be pursued and which options should be favoured in those areas in a clear and consistent way and should introduce a more pro-active approach to delivering HLS.
	To what extent does the implementing body have flexibility in the targeting of the policy measure so that it is adapted to local conditions? ☐ ■ ☐ ☐ ■ Low High Fairly low flexibility for ELS as farmers have a free choice of which options to choose from a nationally set menu and these are not adapted to local conditions, or prioritised locally. However, the availability of the Catchment Sensitive Farming Officers in priority catchments has provided an advice resource on resource protection issues in general – including advising farmers to take up the priority options for resource protection in ELS. High flexibility for HLS, as agreements are developed between farmer and project officer to take account of priority actions needed on the farm. Targeting statements can also be changed if needed, but subject to consultation with stakeholders and agreement with Defra. Significant changes would require Ministerial approval and may require a programme amendment to the Rural Development Programme which would need to be submitted to the Commission.
What Drives Uptake?	Information from the CSL report (2007) suggests that the financial pressures as a result of the 2003 CAP reform had influenced farmers to enter ELS (54 %), with some specifically mentioning the need to recoup money lost through modulation. The main reason for applying to ELS was that it was compatible with existing management practices (51 %), although 45 % mentioned environmental benefits as driving them and 38 % mentioned financial considerations. Reasons for uptake of HLS are not as clear cut although 'financial reward and the benefit to conservation' are stated as being the most positive aspects of the schemes by participants.
	☐ Obligation ■ Financial Incentive ■ Information & support ☐ Exhortation ■ Other
Technical measures	**ELS/OELS**: The farmer has a free choice from a menu of options. Specific options identified for soil protection (reducing risk of runoff and erosion) include: - Management of high erosion risk cultivated land (as identified on FER) – no pigs, root crops, maize, etc. to be cultivated in fields at risk of soil erosion or run off; - Management of maize crops to reduce soil erosion – not available on land at risk of soil erosion or runoff – harvesting and input restrictions; - Buffer Strips and field margins (2-6m buffer strips on cultivated land and intensive grassland and options for buffering in-field ponds in

	arable and improved grassland fields); - Beetle banks – introduced across contours to reduce runoff and erosion. Until recently there was also an option to prepare a soil management plan that went beyond what was required through cross-compliance. However, this has had to be removed for the 2007-13 RDP as it was not approved by the Commission. **HLS**: HLS is a competitive and discretionary scheme. To enter farmers must be able to demonstrate that they can meet the specific targets set for their local area (determined at the Joint Character Area level). Before applying to the scheme, farmers must carry out a Farm Environment Plan, which identifies the key environmental features and priorities on the farm and options should be chosen that address these, thereby tailoring management to the specific situation on the farm. Measures related to soil protection are mainly focused on protecting water courses from diffuse pollution by reducing the risk of soil erosion, nitrate leaching and phosphorus transport. They include: - Arable reversion to unfertilised grassland - Arable reversion to grassland with low fertiliser input - In-field grass areas to prevent erosion or runoff - Preventing erosion or runoff from intensively managed, improved grassland - Seasonal livestock removal on grassland with no input restriction - Nil fertiliser supplement (to support the management of land under the option 'preventing erosion or runoff from intensively management improved grassland' without the use of fertilisers
Enforcement and control	The RPA employs 200 inspectors who are involved in conducting Single Payment Scheme and cross-compliance inspections as well as other CAP scheme inspections. The average time taken for a full inspection by the RPA is about 36 hours with arable farms taking less time to inspect than livestock farms (due to the lengthy checks required for the SMR concerned with animal identification).
Monitoring and evaluation	A joint Natural England and Defra monitoring and evaluation plan has been developed which sets out a number of indicators that the scheme is expected to address. The plan identifies the need to collect not only high level evidence against strategic indicators, but also the collation of farm and field scale information to monitor the success of scheme implementation. The budget is approximately £1.6 million/year, with £1.1 million spent through Natural England and £0.5 million spent through Defra. The monitoring programme is overseen by a steering group consisting of representatives from Defra, Natural England, the Environment Agency and English Heritage. There is also an associated programme of detailed research with funding of £2.5 million/year, designed to inform scheme development and delivery, for example developing and testing management options and techniques that could be incorporated into the scheme, if successful. In the past this has been focused predominantly at biodiversity management, but efforts are being made to extend this to the effective operation of resource protection options.

	In 2007 an evaluation of the introduction of ES, particularly ELS, was undertaken by Central Science Laboratories (CSL), assessing uptake to date, experiences of participants (and non-participants) of the scheme and the potential of ES to deliver against its objectives. In terms of monitoring the resource protection objective of ES (mainly in relation to water quality), an evaluation of the role of management plans within ELS has been carried out (includes soil management plan). However, beyond this, monitoring remains problematic, with significant reliance on qualitative interpretation and modelling of attitudinal and environmental data collected by others (RoP, 2008)
Outcomes of policy measure	Limited information available to date: ELS: The recent CSL evaluation of ES (2007) showed that uptake of resource protection management plans (now no longer options within ELS) was high in comparison to other options, mainly because they were already required for other purposes, such as certification schemes. Spatial analysis has shown that there is greater use of the option for management of high erosion risk land that would be expected by chance, in areas identified by the EA at high/medium risk from sedimentation. In addition, there is a higher than expected incidence of uptake of buffer strip, management plan and high erosion risk options in areas of medium/high risk for phosphorous; and a higher proportion than expected of buffer strips, nutrient and manure management plans in catchments at risk of diffuse pollution by nitrogen. Anecdotal evidence suggests that this may be as a result of the availability of advice through CSF officers in priority catchments, pointing farmers towards priority measures for resource protection. HLS: uptake of resource protection options has been low to date with approximately 200 agreements covering 2,300 hectares. Information from the case study interviews suggests that uptake in the Axe and Parrett catchments is low as farmers do not consider the extra financial reward is sufficient for the extra effort required.
Analysis of drivers of policy measures' outcomes	The introduction of the Water Framework Directive and the need to achieve good ecological status of water bodies was one of the driving forces behind introducing resource protection as an objective within ES in 2005. However, there is continuing tension about which actions farmers should be required to undertake for good soil management and for which it is appropriate to pay an incentive. This is highlighted in the debates in England about what should be covered through cross-compliance and what is justifiable to include within ELS (see other sections for more details), for example the recent removal of all management plan options (soil, nutrient, manure and crop management) from ELS (under request from the Commission during the Rural Development Programme approval process).
Part C – Evaluation of the Policy Measure	
Effectiveness of policy measure (in relation to the extent to which object-tives are achie-ved, and cost-effectiveness)	Very little evidence on this to date – Main evaluation has been the 2007 CSL evaluation of ES which did show a good correlation between areas of risk for diffuse pollution and uptake of resource protection measures in ELS. However, evaluation of resource protection options remains problematic. Uptake figures show high uptake for the soil management plan and nutrient management plans, but these have since been removed from the scheme.

Constraints to achieving full potential of the policy measure	The recent Review of Environmental Stewardship, undertaken by Defra and Natural England, identified a number of issues with the way in which ES, particularly ELS, was operating and put forward recommendations for its improvement. One on the main findings was the need to improve the effectiveness of ES options, to get better cross-sectoral uptake of the scheme and to ensure that there was a better fit of options chosen under ELS with the environmental priorities of the area. As detailed above, the budget is not thought to be sufficient to deliver against all the environmental priorities indentified within England, but there is no separate estimate of cost in relation to resource protection or soils measures. A number of changes to ES have been proposed. Those relating specifically to resource protection measures are listed in 'Recommendation', in Part A of this fiche.
Reasons for the success of the policy measure (where appropriate)	

7.2.3 Fiche 3: Catchment Sensitive Farming Programme in England

Part A: Summary of Measure	
Formal title of measure and date of imple-menttation	England Catchment Sensitive Farming Delivery Initiative (ECSFDI) April 2006 – March 2011 (Initially running only to March 2008, but recently (June 2008) extended for at least three years, with the possibility of a further extension to 2015)
Short description of the measure	The measure applies only to agriculture in England and was introduced to address diffuse water pollution issues, including poor soil management, particularly sedimentation. Its purpose is to encourage early voluntary action by farmers to reduce diffuse water pollution and so contribute to meeting a number of UK policy objectives, including implementation of the Water Framework Directive. The main emphasis is on information, advice and improved awareness of the issues in a series of priority catchments covering about forty per cent of the farmed area in England. There is also an investment aid scheme, known as capital grants schemes in England, in place for a limited period. The scheme has strong links to the resource protection measures in Environmental Stewardship (see Fiche 2). Originally introduced in April 2006 the measure initially ran to March 2008 but has recently been extended, with some amendments announced in June 2008. It is expected to continue to March 2011 or longer, perhaps to 2015. The measure is run by a partnership consisting of the national ministry for both the environment and agriculture, Defra, and two sizeable government environmental agencies with a presence throughout England – the Environment Agency and Natural England.
Type of policy measure	This is principally an information- and capacity- building measure, but it includes an incentive element in the form of a targeted investment aid scheme, the capital grants scheme. The primary intention is to influence

	farmer behaviour and reduce diffuse pollution in forty priority catchments in different parts of England. Ten further catchments are to be added from 2008. It is anticipated that the measure will help to meet the obligations for agriculture arising under the Water Framework Directive, which will be specified more precisely from the end of 2009 in the "Programmes of Measures" which are required under the Directive.
Objective of policy measure and relevance	There are three core objectives: • To increase awareness amongst farmers and other rural land managers and stakeholders of the negative impact of diffuse water pollution from agriculture; • To improve soil and land management practices amongst farmers within the forty "Priority Catchments" and, to a lesser degree, elsewhere; • To reduce water pollution caused by agriculture within these priority catchments. The measure addresses the full suite of diffuse water pollution problems including contamination by pesticides and nitrates, but it does refer explicitly to promoting good soil structure, and the avoidance of runoff and erosion.
	How relevant are the objectives of the measure to the soil degradation threats in your region? ☐ ☐ ☐ ■ ☐ Not very Very The objectives of the measure are very specific to the region, however they do not solely consider soil degradation.
Indirect effects	The measure addresses water quality, flood work and biodiversity concerns as well as soil management. These are supportive of better soil management. Amongst other outputs it aims to encourage a more targeted and effective implementation of the main agri-environment measure in England, which should further benefit soil management.
Linkages to other policy measures	There are specific links to the Water Framework Directive, Environmental Stewardship (see Fiche 2) and a variety of biodiversity measures, some purely national, some relating to EU Directives and others to international agreements – for example, the Ramsar Convention which is concerned with the protection of wetlands.
Funding	The measure is funded nationally (by Defra) as a state aid. The original budget for 2006-08 was set at £25 million, of which £5 million was for the capital grant scheme. However, the budget was cut back to £8.56 million in 2006/07 and £13.28 million in 2007/08. The out turn was slightly lower at £6.59 million in 2006-07 and £7.56 million in 2007-08. The under spend was due to delays in recruiting staff and other factors. Most of the investment aid budget was accounted for (£4.64 million in 2007-08). The funding level would need to be higher for an enlarged programme with ten new priority catchments in the new phase. Defra is providing funding of £12.9 million for the period 08-09, of which £5 million is for capital grants. Funding for 2009-10 and 2010-11 will be confirmed as soon as Defra completes its business planning for these years.

Summary of assessment and conclusions	The measures appear to have been successful in generating greater awareness amongst farmers of a range of diffuse pollution issues, and the soil management practices in connection with these issues. By financing advisory staff on the ground, capacity to address soil management issues has increased, sharpening the focus of other measures, including the capital grants scheme and Environmental Stewardship . Some estimations have been made of the environmental benefits on the ground and the scheme evaluation was very largely positive (see below). It appears to have considerable stakeholder support and it has been extended until 2011.
Recommen-dation	The provision of an active advisory source alongside an investment aid and agri-environment scheme has been a successful formula in the "priority catchments".
Part B: Detail on the Measure's Design, Implementation, Enforcement and Impacts	
Policy design	The ECSFDI is part of Defra's Catchment Sensitive Farming (CSF) Programme, aiming to tackle Diffuse Water Pollution from Agriculture (DWPA) in order to meet the objectives of the Water Framework Directive (WFD). It represents a partnership working between Defra, the two delivery bodies (the Environment Agency (EA) and Natural England (NE)), and stakeholders.
Policy imple-mentation I: Implementatio n at admi-nistrative level	The Programme Board (PB) and Programme Management Group (PMG) are the key governance structures for the ECSFDI at national level, on which Defra, NE and the EA are all represented. Defra is responsible for the ECSFDI and provides the Secretariat for the PB. The PMG is chaired by NE. The PB met eight times between 25 January 2006 and 13 December 2007 and the PMG met twenty-six times between 7 November 2005 and 13 March 2008. The ECSFDI also operates Catchment Steering Groups which meet three/four times each year. They are made up of all or some of the following stakeholders: NE; the EA; the local Catchment Sensitive Farming Officer (CSFO); the local water company; champion farmers; farming organisations or organisations working with farmers, and nature conservation bodies. On the ground, each of the 40 priority catchments has a dedicated advisor or CSFO, whose remit is to work with farmers and promote CSF. These CSFOs were specifically recruited by the ECSFDI as part of the scheme and are consequently funded through it. There are currently 42 CSFOs and a further five are due to join the existing network from autumn 2008.
Policy implementatio n II: Method of delivery to far-mers	CSFOs provide or coordinate the provision of a range of advice and support to farmers including: • Farmer workshops, seminars, meetings, demonstrations and walks; • Workshops and seminars for farming advisers; • One-to-one advice either on-farm or through farmer 'clinics'; • Whole farm appraisal; • Soil, nutrient and manure management plans; • Farm infrastructure audits;

	• Advice on slurry handling and storage; • Soil, manure and slurry sampling analysis; and • Grants towards the cost of DWPA control measures; To support CSFOs in the delivery of advice to land managers and their advisors, a framework agreement was established in November 2006 with thirteen specialist advice providers. Delivery of pesticide advice is also supported and implemented by the Pesticide Voluntary Initiative (VI) and focussed primarily on seven priority catchments.
Targeting	The measure is targeted at 40 priority catchments, covering a total area of 40,964km^2, which were identified, after technical assessment, by the EA and EN. These catchments are subject to change and, over the lifetime of the Initiative, new catchments may be added and some removed as a result of further technical assessment. In larger catchments, advice delivery focuses primarily on sub-catchments of the highest priority (Target Areas) or key farming sectors (Target Sectors), identified through a Catchment Appraisal process. A further ten Target Areas are proposed in the extension to the scheme period to 2011. The ECSFDI also contributes to 20 'Associate CSF' projects led by other organisations which fall outside the 40 priority catchment areas.
	To what extent does the implementing body have flexibility in the targeting of the policy measure so that it is adapted to local conditions? ☐ ☐ ☐ ☐ ■ Low High
What Drives Uptake?	CSF is purely voluntary and there is no obligation to uptake the measures advocated by the ECSFDI. However there is a Capital Grant scheme that will provide up to 60 % funding for certain projects, so a financial incentive is key to uptake, as cited by interviews in the Axe & Parrett catchment areas. Recipients of the scheme also cite the provision of advice as a significant driver, as it enables them to better understand the management processes applied on their farms, and they can witness the effects of advised measures on the visible degradation processes in the area.
	☐ Obligation ■ Financial incentive ■ Information & support ■ Exhortation ☐ Other
Technical measures	Over 14,000 farm-specific recommendations were made for improving soil and land management to control diffuse water pollution. The majority of DWPA mitigation methods planned and/or implemented overall were for fertiliser management (40 %). Soil management methods were second, at around 24 %, with the remaining methods comprising manure management (~18 %), farm infrastructure (~10 %), livestock management (~5 %), pesticide management (~2.5 %) and land use (~0.5 %). Regionally the emphasis changed between categories. For example in Anglia, soil management was the dominant category accounting for ~65 % of mitigation methods.

Enforcement and control	Measures undertaken by farmers to promote CSF are purely voluntary. However, where they have succeeded in gaining a capital grant, farmers should be prepared for inspections by the EA until March 2014.
Monitoring and evaluation	A comprehensive evaluation of Phase 1 (2006-2008) has been undertaken by Defra. The monitoring and evaluation is being assessed through: 1. Farmer engagement – quantifying the amount of advice provided to land managers and their advisers 2. Changes to farmer awareness and attitude – surveying farmers to determine the extent to which engagement has resulted in behavioural change, essential to optimise environmental outcomes. 3. Changes in farming practice – quantifying what happens on farms to reduce DWP as a result of the ECSFDI 4. Reduction in pollution load – estimating reductions in diffuse pollution entering watercourses as a result of the ECSFDI 5. Improvements in water quality – modelling changes in water quality and progress achieved towards the Water Framework Directive objectives. A baseline survey of 1000 farmers within the 40 catchment areas was undertaken in January/February 2007 and was repeated in November 2007. The main assessment methods were: • Telephone surveys of farmers attitudes and awareness • Self-completion survey forms from farmers receiving advice • Farmer case studies • A database of farmer engagement and take up of measures for controlling DWP • Modelling of landscape losses of pollutants • Water quality monitoring and modelling
Outcomes of policy measure	Farmer engagement was seen as highly effective, with 6,119 farmers receiving advice through 517 group events, 147 advice clinics and 4,736 one to one visits to 3,527 different farm holdings. This represents 15 % of all farm holdings within the 40 priority catchment areas and 34 % of holdings in the Target Areas. Knowledge regarding DWPA increased, with 80 % of farmers who received ECSFDI advice confirming that their knowledge of water pollution had increased and that they have taken, or intend to take, action to reduce water pollution. There is, however, still limited acceptance from farmers that agriculture makes a significant contribution to water pollution. Uptake of the Environmental Stewardship Entry Level Scheme has been higher in ECSFDI catchments than outside the catchment areas and the Capital Grant Scheme has contributed £4.65 million towards priority farm improvements. Various outcomes of the ECSFDI have been predicted using modelling techniques. These indicate that there will be significant reductions in agricultural nutrient, sediment and pathogen losses. At the catchment scale reductions are on average less than 10 %, however some catchments reach 20 to 40 %. Predicted reductions of in-river phosphorus

	loads and concentrations were generally <5 % at the catchment scale although reductions of 20-30 % were predicted from some catchments. Predicted in-river reductions in total nitrogen were generally higher than for phosphorus, attributed to greater uncertainty in the model but also a lesser influence of point source pollution. At catchment scale, reductions of 5-10 % were predicted. Pesticide modelling predicted an overall reduction in pesticide occurrences above a 0.1µgl^{-1} threshold in water of between 0-10 %. These figures and considerations were obtained from Defra's consultation[40] in 2007, and they focus mainly on diffuse water pollution and associated water system effects, rather than on soil conservation. The case study interviews in the Axe and Parrett provided positive considerations of increases in soil conservation awareness, and of positive effects on agricultural soil, including the reversal of soil degradation processes. Monitoring and evaluation of these specific soil-related issues is still necessary to demonstrate clear evidence and justify continued funding.
Analysis of drivers of policy measures' outcomes	There has been a decline recently in local advisory services in the UK, and the ECSFDI has partially reversed this trend. All stakeholders in the case study catchment areas consider the local-level consultation and advisory services provided by CSF as highly effective and targeted. Consultation at all levels of the agricultural spectrum (i.e. from farmers to delivery bodies) is a significant priority of Defra's soil-related objectives, and the ECSFDI is helping to address this both in terms of delivering advice and expertise to farmers, and to the delivery bodies themselves, through feedback from the advisory services. It is still, however, considered by stakeholders in the case study catchments that this level of feedback from action and results on the ground can increase, in order to inform higher policy actors of successes, failures, and long-term planning. The only concerns reported in the case study catchments with regards to the funding provided by the capital grants scheme for the targeted initiatives within CSF, is that the funding is not available long-term, over a suitable timescale for planning the future extent and coverage of the initiative. However, these concerns should have been assuaged since Defra announced the continuation of CSF until 2011, with funding of £12.9 million for the ECSFDI in 2008-09, of which £5 million is for capital grants. Funding for 2009-10 and 2010-11 will be confirmed as soon as Defra completes its business planning for these years.
Part C – Evaluation of the Policy Measure	
Effectiveness of policy measure (in relation to the extent to which objectives are achieved, and cost-effectiveness)	The ECSFDI has only been running for two years, a relatively short timescale which makes it difficult to evaluate effectiveness. It certainly appears to be filling a gap in the suite of policy measures available to tackle DWPA and soil pollution. The evaluations of reductions in agricultural, nutrient, sediment and pathogen losses have all been achieved using models and consultation responses from stakeholders, which make the results less reliable than empirical data from the field. There is a need for more empirical evidence, particularly relating to agricultural soil, to inform reliable conclusions. However, it appears that

[40] http://www.defra.gov.uk/farm/environment/water/csf/pdf/diffuse-consult-govresponse.pdf

	the policy measure is proving effective in meeting its three objectives. Firstly, it has raised awareness amongst farmers and other rural land managers and stakeholders of the negative impacts of DWPA; secondly, some of this awareness has translated into improved soil and land management practices; and finally there has been a predicted reduction in water pollution caused by agriculture within the priority catchments. The scheme can therefore be said to be cost-effective. Effectiveness on soil conservation awareness and practice is promoted by CSFOs and stakeholders in the Axe and Parrett catchments, and Defra confirm that they have received positive (informal) reviews of this focus, nationally.
Constraints to achieving full potential of the policy measure	The Capital Grant scheme attached to the ECSFDI was oversubscribed, with £5m available for grants and £11m applied for, therefore only a limited number of farmers who were intending to make DWPA-mitigating investments could do so. The proposed budget for the Capital Grant scheme for 2008 remains at £5 million however, and has not been increased at all in line with demand. The policy measure is limited to achieving its full potential as it only operates in a limited number of catchment areas. The number of these is set to rise in the second phase of the ECSFDI, adding a further ten to the original 40.
Reasons for the success of the policy measure (where appropriate)	Regionally-applicable targeting, using expert opinion and research, increases the appropriateness and effectiveness of the scheme's measures to the region's degradation processes. Funding for the capital investment required by the scheme's measures is key to uptake by farmers. Farmers and land managers are positive that they learn from the provision of advice and there is improved understanding of both the environmental and economic rationale for soil conservation. The techniques of advice provision are well regarded, as is the level of trust in the advisors helping them to implement the measures. Such a positive outlook on the scheme encourages more complete and prompt uptake of the measures. The policy measure has been enough of a success to be continued from 2008 to 2011, and possibly 2015.

7.3 Summary of policy use and effectiveness

The fiches provide a summary of the three most important policy measures with regard to soil management. There is relatively little empirical data to establish which approaches are most effective in terms of results on the ground so most of the judgements made by stakeholders are rather qualitative. A combination of measures is generally seen as necessary with advice, support and sustained engagement with the farming community critical to success. The triangle of agri-environment incentive schemes, cross compliance and the multi-stranded CSF initiative that has emerged in recent years is considered a considerable advance on the previous pattern of interventions which was more limited and appears to have had less impact. The combination of cross compliance and CSF has raised farmers' awareness of soil degradation problems and potential remedial measures and created some momentum, reinforced by other measures, such as the Nitrates Directive and prosecutions mounted against farmers who have allowed significant off-site damage, such as quantities of mud on the road. At the same time, the limitations of policy measures as an instrument to influence soil management must be emphasised, especially as it is difficult to monitor precisely how farmers are managing their soils without a higher level of presence of advisers or inspectors on the ground.

With regard to individual measures:

a.) Cross compliance introduced GAEC requirements that appeared very relevant to the major soil degradation issues and compliance levels are reported to be relatively high. The SPR appears to have been a useful innovation, generally requiring the farmers themselves to focus more on soils than usual, although many complain about the extra burden placed on them. As in other countries it is early to judge the effectiveness of GAEC after a short period, although a substantial number of SPRs have been prepared and these are considered useful by the regulatory agencies.

b.) Environmental Stewardship (ES). This three tiered incentive scheme is more popular with farmers than cross compliance, not surprisingly, but traditionally has not been very focused on soils. This changed in 2005 with an explicit reference to resource protection, including soil conservation in the scheme objectives. Since then, ELS monitoring results are not available so limiting the scope for evaluating the impact on soils.

The lack of close targeting of the soil related measures is a weakness since farmers in areas with recognised problems are not required to address these by choosing soil related prescriptions under ES, although CSF officers encourage them to do so. There is the option for farmers to choose other less demanding or more remunerative ES prescriptions and many decide to do so.

By contrast, Higher Level Stewardship (HLS) is targeted more on specific farm conditions, including soil degradation problems. It is more administratively demanding and more constraining of farmers management freedom. The payment rates have not been sufficiently high to attract many farmers into the scheme, which has suffered from budget constraints as well. In short, there is considerable scope for achieving more with this policy instrument.

Encouragingly, ES is considered much more effective in CSF priority catchments including the Axe and Parrett due to the provision of advice on the options, which is lacking outside the priority catchments. So there is scope to promote this approach more widely by an enhanced advisory and aid service.

c.) Catchment Sensitive Farming. This measure, which includes both advice and capital grants is popular with both farmers and other stakeholders who consider that it enhances the effectiveness of other measures as well as delivering results in its own right.

- anecdotal evidence on the impacts are very positive – for farmers, stakeholders and local delivery actors
- however, anecdotal evidence is still not reinforced by empirical evidence – relatively new scheme and monitoring results are limited

All interviewees at the local level feel that there is a lack of funding hindering the progress of CSF. Some of the reasons given relate to short term implementation issues, such as better training particularly on technical issues. Whether or not this is primarily a funding issue, it certainly puts constraints upon implementation. Others call for cohesive, planned, long-term funding so that the effectiveness of the scheme is not stunted by uncertainty. Defra's announcement of funding for CSF until at least 2011 will assuage some of the concerns.

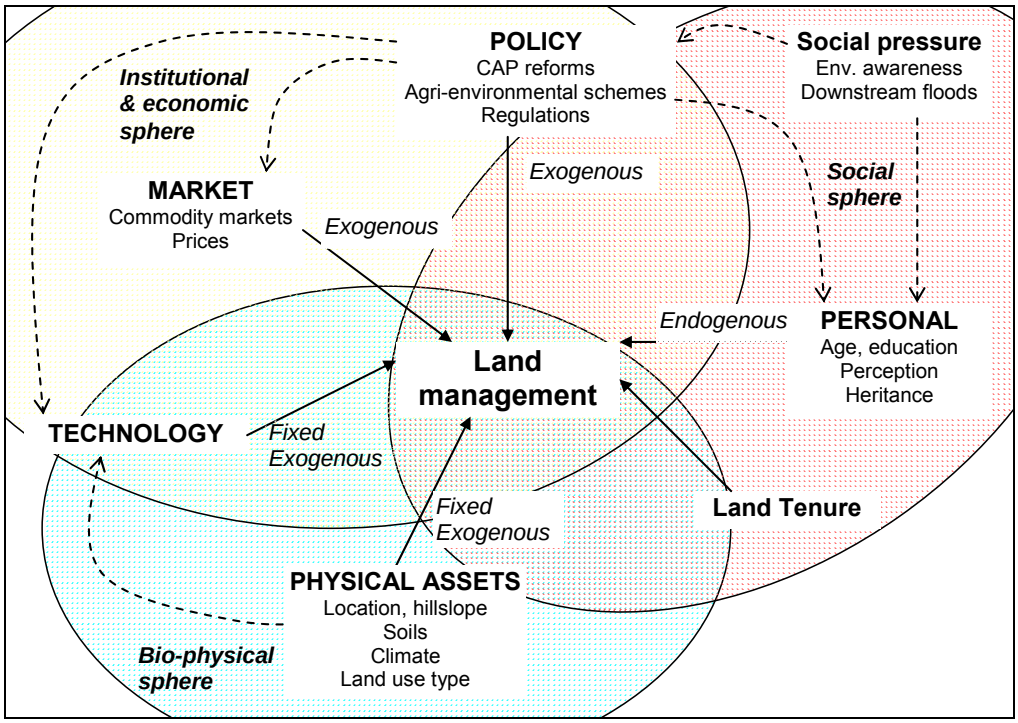
In addition, the Water Framework Directive (WFD) is often cited as an important policy influencing soil conservation, not necessarily in a direct sense but more as a major driver behind CSF and other policy measures that may follow. The focus on diffuse water pollution provides additional impetus to conserve soils and reduce erosion. This underlines the fact that there are clear synergies between policies for soil and water in the agriculture sector, reinforced by the strategic role of the Environment Agency in both areas.

One feature of policy development and implementation in the case study welcomed by stakeholders and government agencies was the much greater emphasis on consultation and involvement with farmers in recent years. This has altered the conditions for policy making and increased goodwill considerably.

8 Conclusions

Within the Axe and Parrett catchments, five soil degradation processes have been identified; soil compaction, soil erosion, diffuse contamination, reduction in water retention capacity and decline in organic matter. Of these, soil compaction and soil erosion are considered to be the most significant. The main cause of this soil degradation is considered to be the intensification of agricultural production within these predominantly rural catchment areas. Agriculturally the catchments are dominated by pasture for dairy, beef and sheep production, but arable crops are grown both as fodder crops for the animals and as cash crops. In particular it is the late cropping of maize and winter wheat, when the soils are wet and therefore susceptible to compaction and smearing, that causes some of the worst structural damage on heavier soils. On lighter soils, fine seedbed preparation and the use of irrigation that has brought into production high erosion risk fields, for premium priced crops such as potatoes, has increased the risk of soil capping, surface runoff and soil erosion. Soil degradation is not exclusively linked to arable production. Intensification of pasture and extending the grazing season into early autumn, when the soil is getting wetter, has increased the pressure on the soil, leading to shallow subsurface compaction and surface poaching, both of which lead to an increase in surface runoff (Deeks et al., in press). Inappropriate management of farmyard manure is also a concern.

Figure 8: Factors influencing farmers' decision-making on land management



Source: Posthumus and Morris, 2007

Although soil degradation is a physical process, the underlying causes are to be found in the social, economic, political and cultural context in which farmers operate (Blaikie, 1985; Boardman et al., 2003; Enters, 1999; Stocking and Murnaghan, 2001). Figure 8 presents a conceptual model of factors that influence decision-making at farm level on land management. The availability and characteristics of technology define its uptake. Physical assets determine the bio-physical boundaries within which land management takes place. Policy and markets are external factors influencing land management, as land managers respond to prices to keep their enterprises viable, and to policy, including those measures which coincide with their objectives. Internal factors such as farmers' attitudes and characteristics are also important for understanding their land management decisions (Ervin and Ervin, 1982; Lynne et al., 1988; O'Connell et al., 2004; Wilson, 1996).

Over the past decade, soil degradation has generally been increasing in the case study catchments and in other rural areas in the UK. However, in the last 2 to 3 years a reversal in this trend has begun as better land management advice has been made available and taken up, moving beyond the broad-spectrum, voluntary agri-environment scheme model which was heavily relied on previously. Now policies have made an impact, particularly through increasing farmer engagement at a time when the pressures to intensify may be increasing with higher commodity prices.

Although agri-environment schemes can 'buy' an alteration in farming practice, a change in attitude of the land managers is needed to secure the intended outcomes over the longer term. This can be achieved by showing the additional value of a management practice on top of any subsidy received for managing the area and underlines the importance of advice alongside incentive measures. There were two examples of this in the case study catchments. Firstly, appropriate use can be made of a cover crop, by providing additional savings through extra fodder or income, and also utilising nutrients that may otherwise have been leached at vulnerable times. Secondly, better nutrient management and cost savings can be made through utilising available organic fertiliser and reducing the demand for inorganic fertiliser. This has the added advantage of reducing excess nutrient build-up in the soil, and when used in combination with minimum tillage can increase organic matter content.

Stakeholders consulted in the Axe and Parrett catchment areas generally believe that current soil conservation legislation and policy has improved but is still disjointed and in the process of evolving. Although a number of policies address soil conservation issues, gaps remain in the implementation of effective, targeted measures. While there are calls for improvements to current policy, this does not amount to a universally accepted solution, however. Some consider that a major new soil focussed policy initiative would be the most effective option to address the gamut of degradation processes, while others feel that targeted improvements to existing policies could address the issues collectively, and more effectively. All agree that greater stakeholder consultation is essential.

References

ADAS (2007): Diffuse nitrate pollution from agriculture – strategies for reducing nitrate leaching. ADAS report to Defra, supporting paper D3 for the consultation on implementation of the Nitrates Directive in England. Available at: http://www.defra.gov.uk/environment/water/quality/nitrate/pdf/consultation-supportdocs/d3-inventory-measures.pdf.

AEA (2007): Industry facts. Agricultural Engineers Association, economics Department. Available at: http://www.aea.uk.com/industry_facts.htm.

Ansorge, D. and Godwin, R.J. (2007): The effect of tyres and rubber track at high axle loads on soil compaction. *Biosystems Engineering* 98(1), pp. 115-126.

Bellamy, P.H., Loveland, P.J., Bradley, R.I, Lark, R.M. and Kirk G.J.D. (2005): Carbon losses from all soils across England and Wales 1978-2003. *Nature* 437, 245-248

Beven, K., Young, P., Romanowicz, R., O'Connell, E., Ewen, J., O'Donnell, G., Holman, I., Posthumus, H., Morris, J., Hollis, J., Rose, S., Lamb, R. and Archer, D. (2008): Analysis of historical data sets to look for impacts of land use and management change on flood generation. Project FD2120. Defra.

Blaikie, P. (1985). *The political economy of soil erosion in developing countries*, Long Development Studies.

Boardman, J., Burt, T. P., Evans, R., Slattery, M. C. and Shuttleworth, H. (1996): Soil erosion and flooding as a result of a summer thunderstorm in Oxfordshire and Berkshire, May 1993. *Applied Geography* 16, pp. 21-34.

Boardman, J., J., Poesen and R. Evans (2003): Socio-economic factors in soil erosion and conservation. *Environmental Science & Policy* 6: 1-6.

Boardman, J. and Evans, B. (2006): Britain. In: Poesen, J. and Boardman, J. (eds): Soil Erosion in Europe. Wiley, Chichester.

Catt, J.A., Howse, K.R., Christian, D.G., Lane, P.W., Harris, G.L. and Goss, M.J. (2000): Assessment of tillage strategies to decrease nitrate leaching in the Brimstone Farm Experiment, Oxfordshire, UK. *Soil and Tillage Research* 53, pp. 185-200.

Clarke, M.A., Creamer, R.E., Deeks, L.K., Gowing, D.J.G., Holman, I.P., Jones, R.J.A., Palmer, R.C., Potts, S.G., Rickson, R.J., Ritz, K., Smith, J., Thompson, T.R.E., Truckell, I.G., Vickery, J., Whalley, W.R., Whelan, M.J. and Woodcock B.A. (2008): Scoping study to assess soil compaction affecting upland and lowland grassland in England and Wales. Final project (BD2304) report to Defra.

Colman, D. (1994): Comparative evaluation of environmental policies; ESAs in a policy context. In: Whitby, M. (ed.): Incentives for countryside management; the case of Environmentally Sensitive Areas. CAB International, Wallingford, pp. 219-251.

Comfort, S.D., Kelling, K.A., Keeney, D.R. and Converse, J.C. (1990): Nitrous oxide production from injected liquid dairy manure. *Soil Science Society of America Journal* 54, pp. 421-427.

Cuttle, S.P., Haygarth, P.M., Chadwick, D.R., Newell-Price, P., Harris, D., Shepherd, M.A., Chambers, B.J. and Humphry, R. (2006): An inventory of measures to control diffuse water pollution from agriculture (DWPA), user manual, Defra.

Davies, B.B. and Hodge, I. (2006): Farmers' preferences for new environmental policy instruments: determining the acceptability of cross compliance for biodiversity benefits. *Journal of Agricultural Economics* 57(3), pp. 393-414.

Deeks, L.K., Clarke, M.A., Holman, I.P., Howden, N.J.K., Jones, R.J.A., Thompson, T.R.E. and Truckell, I.G. (in press): What effect does soil compaction in grassland landscapes have on rainfall infiltration and runoff? *Seesoil*, Journal of the South East England Soils Discussion Group.

Defra (2000): Fertiliser recommendations for agricultural and horticultural crops (RB209): Seventh edition. Department for Environment Food and Rural Affairs. Available at:: http://www.defra.gov.uk/farm/environment/land-manage/nutrient/fert/rb209/index.htm

Defra (2002): The welfare implications of extended grazing. Campaigns for 2001/2002. Available at www.defra.gov.uk/animalh/welfare/farmed/advice/, June 2008.

Defra (2007a): June 2006 Agricultural and Horticultural Survey Statistics – England. Department for Environment, Food and Rural Affairs, National Statistics. Available at: http://www.defra.gov.uk/esg/work_htm/publications/cs/farmstats_web/2_SURvey_data_search/complete_datasets/regional_level_datasets.htm.

Defra (2007b): Catchment priorities. Catchment Sensitive Farming. Available at: http://www.defra.gov.uk/farm/environment/water/csf/catchments/priority/index.htm.

Defra (2007c): Environmental planning of short rotation coppice and miscanthus. Available at: http://www.defra.gov.uk/farm/crops/industrial/energy/opportunities/environmental-planning.htm, June 2008.

Defra (2007d): Agriculture in the UK. Available at: http://statistics.defra.gov.uk/esg/publications/auk/2007/14%20AUK%202007%20Chapter%2013.pdf.

Enters, T. (1999): Incentives as policy instruments; key concepts and definitions. In: Sanders, D.W., Huszar, P.C., Sombatpanit, S. and T. Enters: *Incentives in soil conservation: from theory to practice*. WASWC, Science Publishers Inc.

Ervin, C.A. and D.E. Ervin (1982): Factors affecting the use of soil conservation practices: hypotheses, evidence, and policy implications. *Land Economics* 58(3), pp. 277-291.

Driessen, P.M. and R. Dudal (1991): The major soils of the world. Agricultural University Wageningen, Katholieke Universiteit Leuven. Koninklijke Wöhrman BV, Zutphen.

Evrard, O., Persoons, E., Vandaele, K. and van Wesemael, B. (2007): Effectiveness of erosion mitigation measures to prevent muddy floods: a case study in the Belgian loam belt. *Agriculture, Ecosystems and Environment* 118, pp. 149-158.

Frost, J.P. (1984): Some effects of machinery traffic on grass yield. In: Nelson, J.K. and Dinnis, E.R. (eds.): Machinery for Silage. British Grassland Society, occasional symposium nº 17, York, United Kingdom, pp. 18-25.

Harris, G.L., Clements, R.O., Rose, S.C., Parkinand, A. and Shepherd, M. (2004): Review of impacts of rural land use and management on flood generation. Impact study report. Appendix C: Current state of managed rural land and mitigation measures. Joint Defra/EA Flood and Coastal Erosion Risk Management R&D Programme. Available at: http://sciencesearch.defra.gov.uk/Default.aspx?Menu=Menu&Module=FJPProjectView&Location=None&ProjectID=10718&FromSearch=Y&FieldOfStudy=12&SearchBy=3&SearchText=2114&ShowDocuments=1&SortString=ProjectCode&SortOrder=Asc&Paging=10&FJP=1.

Heathwaite, A.L., Burt, J.P. and Trudgill, S.T. (1990): Land use controls on sediment production in a lowland catchment, southwest England. In: Boardman, J., Foster, I.D.L. and Dearing, J.A.): Soil Erosion on Agricultural Land. J. Wiley, Chichester, pp. 69-86.

Heathwaite, A.L., Quinn, P.F. and Hewett, C.J.M. (2005): Modelling and managing critical source areas of diffuse pollution from agricultural land using flow connectivity simulation. *Journal of Hydrology* 304 (1-4), pp. 446-461.

IEEP (Institute for European Environmental Policy) (2007): Cross Compliance Evaluation Report.

Ingram, I. (2008) Are farmers in England equipped to meet the knowledge challenge of sustainable soil management? An analysis of farmer and advisor views. *Journal of Environmental Management* 86, pp. 214-228.

Jorajuria, D. and Draghi, L. (1997): The distribution of soil compaction with depth and the response of a perennial forage crop. *Journal of agricultural Engineering Research* 66, pp. 261-265.

Kleijn, D. and Sutherland, W.J. (2003): How effective are European agri-environment schemes in conserving and promoting biodiversity? *Journal of Applied Ecology* 40:, pp. 947-969.

Lynne, G.D., Shonkwiler J.S. and L.R. Rola (1988): Attitudes and farmer conservation behavior. *American Journal of Agricultural Economics*.

MAFF (Ministry of Agriculture, Fisheries and Food) (1998): The Water code. Code of good agricultural practice for the protection of water. Available at: http://www.defra.gov.uk/farm/environment/cogap/pdf/watercod.pdf.

Met Office (2008): Climate 1971-2000 averages. Available at: http://www.metoffice.gov.uk/climate/uk/averages/19712000/sites/yeovilton.html.

Morgan, R.P.C. (1985). Assessment of soil erosion risk in England and Wales. *Soil Use and Management* 1, pp. 127-131.

Morgan, R.P.C. (1995): Soil erosion and its control. Longman Scientific and Technical, Harlow.

Morris, C. and Potter, C. (1995): Recruiting the new conservationists: farmers' adoption of agri-environmental schemes in the UK. *Journal of Rural Studies* 11(1), pp. 51-63.

Morris, J., Mills, J. and Crawford, I.M. (2000): Promoting farmer uptake of agri-environment schemes: the Countryside Stewardship arable options scheme. *Land Use Policy* 17:, pp. 241-254.

NSRI (National Soil Research Institute) (2001): A Guide to Better Soil Structure. National Soil Resources Institute, Cranfield University at Silsoe, Bedford, UK. Available at www.soil-net.com/legacy/downloads/resources/structure_ brochure.pdf, June 2008.

O'Connell, P.E., Beven, K.J., Carney, J.N., Clements, R.O., Ewen, J., Fowler, H., Harris, G.L., Hollis, J., Morris, J., O'Donnell, G.M., Packman, J.C., Parkin, A., Quinn, P.F., Rose, S.C., Shepherd, M. and S. Tellier (2004): *Review of impacts of rural land use and management on flood generation*. R&D Technical Report FD2114. London, DEFRA.

Palmer, R.C., Burton, R.G.O., Hannam, J.A. and Creamer, R. (2006): Comparison of soil structural conditions in Tone and Parrett catchments during winter periods 2002-03 and 2005-06. BSRI research report No. YE 200039V for JAF Project, FWAG (Somerset) and Environment Agency, 50p.

Peigné, J., Ball, B.C., Roger-Estrade, J. and David, C. (2007) Is conservation tillage suitable for organic farming? A review. *Soil Use and Management* 23, pp. 129-144.

Posthumus, H., Hewett, C.J.M., Morris, J. and Quinn, P.F. (in press): Agricultural land use and flood risk management: engaging with stakeholders in North Yorkshire. *Agricultural Water Management.*

Posthumus, H. and Morris, J. (in press): Implications of CAP reform for land management and runoff control in England and Wales. *Land Use Policy.*

Posthumus, H. and Morris, J. (2007) Flood risk management policy issues, Volume 1 - rural. FRMRC Research Report UR8. Flood Risk Management Research Consortium, Manchester

Robinson, M. (1990): Impact of improved land drainage on river flows. Institute of Hydrology, Report 113.

Scholefield, D. and Hall, D.M. (1985): A method to measure the susceptibility of pasture soils to poaching by cattle. *Soil Use and Management* 1, pp. 134-138.

Smith, K.A., Jackson, D.R. and Withers, P.J.A. (2001): Nutrient losses by surface runoff following the application of organic manures to arable land. 2. Phosphorus. *Environmental Pollution* 112, pp. 53-60.

Smith, R. (2007): Personal communication. Environment Agency. 28 June 2007.

Stocking, M. and N. Murnaghan (2001). *Handbook for the field assessment of land degradation*. London, Earthscan.

SW Observatory (2007): Hedgerows. Available at http://www.swenvo.org.uk/environment/hedgerows.asp.

Walford, N. (2002): Agricultural adjustment: adoption of and adaptation to policy reform measures by large-scale commercial farmers. *Land Use Policy* 19, pp. 243-257.

Wilson, G.A. (1997): Factors influencing farmer participation in the Environmentally Sensitive Areas scheme. *Journal of Environmental Management* 50, pp. 67-93.

Wilson, G.A. (1996): Farmer environmental attitudes and ESA participation. Geoforum 27(2), pp. 115-131.

Wilson, G.A. and Hart, K. (2001): Farmer participation in agri-environment schemes: towards conservation-oriented thinking? Sociologia Ruralis 41(2), pp. 254-274.

Withers, P.J.A., Hodgkinson, R.A., Bates, A. and Withers, C.L. (2007) Soil cultivation effects on sediment and phosphorus mobilization in surface runoff from three contrasting soil types in England. *Soil and Tllage Research* 93, pp. 438-451.

Younie, D. (2001): Organic and conventional beef production – a European perspective. Paper presented at 22nd Western Nutrition Conference, University of Saskatchewan, Saskatoon, Canada, September 2001. Available at http://www.sac.ac.uk/mainrep/pdfs/organicbeef, June 2008.

Annexes

Interviewees in the Axe and Parrett catchments

Interview Date	Interviewee (affiliation/position)	Type of interview
9/04/08	Axe Catchment Farmer	face-to-face
	Axe Catchment Farmer	face-to-face
11/04/08	Axe Catchment Farmer	face-to-face
9/04/08	Catchment Advisor, River Axe, FWAG	face-to-face and email
11/04/08	Catchment Advisor, River Axe, CSF	face-to-face and telephone
15/04/08	Environment Manager, regional water company	face-to-face
16/04/08	Land Drainage Officer, District Council	face-to-face
	Environment Officer, the Environment Agency	face-to-face
	Two Catchment Sensitive Farming Officers (Somerset Levels & Moors, Parrett), Natural England & the Environment Agency	face-to-face
17/04/08	Environment Manager, regional water company	face-to-face
	Catchment Advisor/Officer, River Axe, FWAG	face-to-face
	Regional Environmental Policy Adviser, NFU	face-to-face
18/04/08	Catchment Advisor/Officer, River Parrett, FWAG	face-to-face
	Independent Advisor/Director/Lobbyist, associated with various stakeholders e.g CPRE, the Wildlife Trust	face-to-face
21/04/08	Farm Services Advisor, Independent	telephone
	Parrett Catchment Farmer	face-to-face
	Parrett Catchment Farmer	face-to-face
	Parrett Catchment Farmer	face-to-face
24/04/08	Catchment Advisor, River Parrett, CSF	telephone
28/04/08	Regional Officer, RSPB	telephone
20/05/08	Principal Officer for Land Quality, South West, the Environment Agency	telephone
21/05/08	Deputy Head of Agriculture, the National Trust	telephone
27/05/08	Senior Specialist – Geology, Landscape & Soils, Natural England	telephone
27/05/08	National Environment Policy Advisor, NFU	telephone
28/05/08	Head of Soils Policy; Senior Scientific Officer on Soils Policy, Defra	face-to-face

20/06/08	Senior Principal Scientist, ADAS	telephone
23/06/08	Policy Lead: Cross-compliance and environmental standards in farming, Defra	telephone
23/06/08	Executive Officer, SPS Operations, the Rural Payments Agency	telephone

Overview of the results of Questionnaire 1

Main farm types	arable, livestock
Main crops	maize (fodder), grass, cereal, wheat, oilseed, carrot, pea, beet and turnip (fodder), barley, potato, strawberry, triticale (fodder)
Livestock	bovine (races: Devon Reds, South Devon), sheep (races: Poll Dorset, Blackface, Whiteface), chicken
Main production orientation	conventional
Average field size	6 ha (Somerset: 9,5 ha)
Irrigation methods	center pivot ('gun') for potato if dry summer; trickle / drip irrigation for strawberry
Source of irrigation water	rivers
Usual salt content of irrigation water	not significant
Drainage systems	tube systems, ditches
Existing grass strips	yes
Separation of fields by hedges	yes
Main soil degradation processes	soil erosion, diffuse soil contamination, decline in organic matter, compaction, Reduction in water retention capacity
Applied soil conservation measures (cropping/ tillage measures)	intercrops, undersown crops, grass strips, reduced tillage, contour tillage, restriction of row crops on steep slopes, wheel sizes and pressure / restricting excessive heavy machinery use, restrictions on the max. amount of (liquid) manure application, restrictions on the max. amount of N- fertilisation, controlled livestock movement
Applied soil conservation measures (long term measures)	liming, drainage management to mitigate salinisation and/or compaction, controlled traffic tramlines, retention ponds, hillside ditches, subsoiling, adjusting stocking rates, adjusting duration and season of grazing animals

Figure 9: Uptake of Environmental Stewardship in the Axe and Parrett catchments

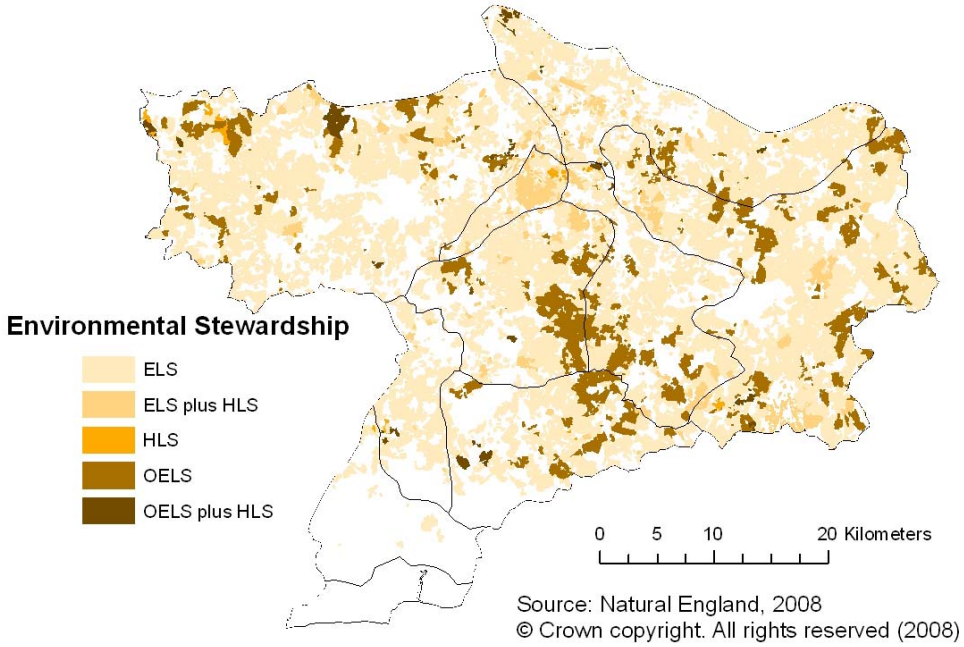


Figure 10: Nitrate Vulnerable Zones in the Axe and Parrett catchments

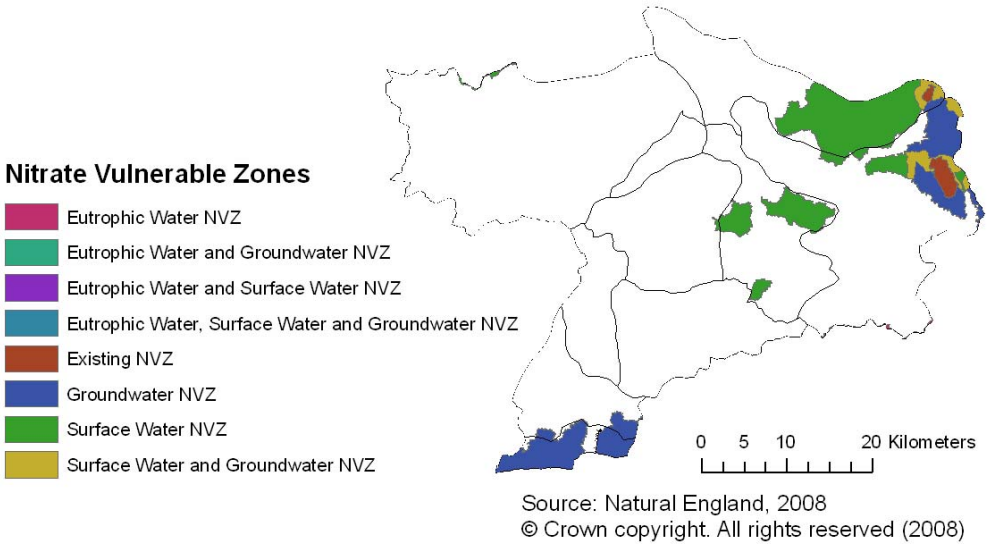
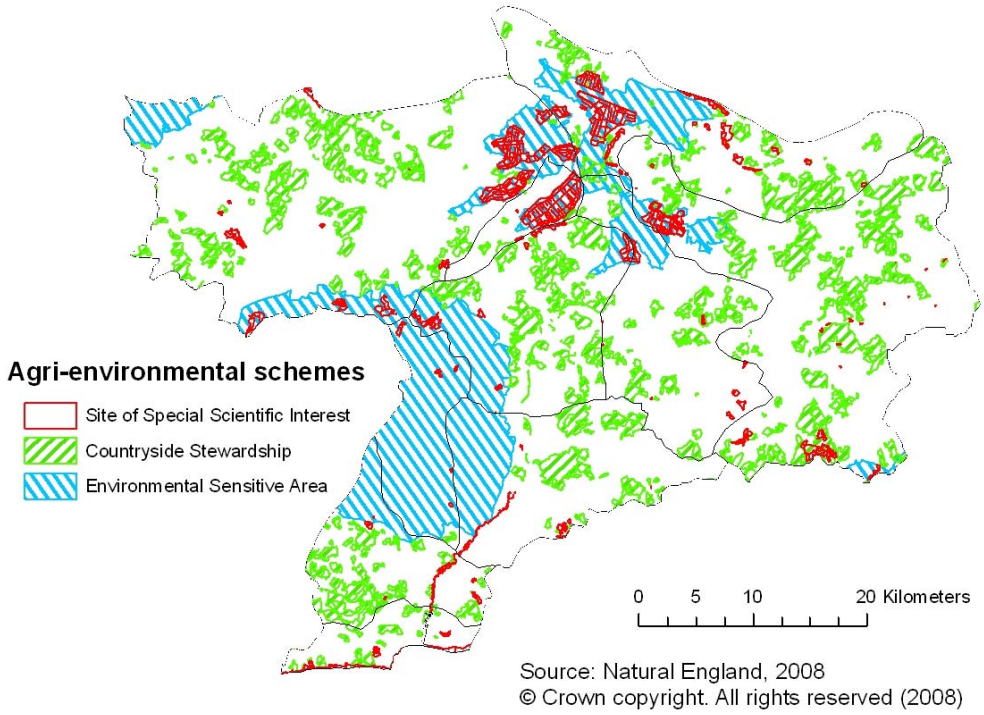


Figure 11: Agri-environmental schemes in the Axe and Parrett catchments



Source of Figures 9-11: Natural England (2008) GIS digital boundary datasets. http://www.english-nature.org.uk/ pubs/gis/GIS_selection.asp?Type=1. Last accessed June 2008

European Commission

EUR 24131 EN/10 – Joint Research Centre – Institute for Prospective Technological Studies
Title: Case Study – United Kingdom, Sustainable Agriculture and Soil Conservation (SoCo Project)
Author(s): Lynda Deeks, Helena Posthumus, Jane Rickson, Ian Fenn, Catherine Bowyer, David Baldock, Nicole Heyn

Luxembourg: Office for Official Publications of the European Communities
2009
EUR – Scientific and Technical Research series – ISSN 1018-5593
ISBN 978-92-79-14959-7
DOI 10.2791/39515

Abstract

This Technical Note 'Case Study – United Kingdom' is part of a series of case studies within the 'Sustainable Agriculture and Soil Conservation' (SoCo) project. Ten case studies were carried out in Belgium, Bulgaria, the Czech Republic, Denmark, France, Germany, Greece, Italy, Spain and the United Kingdom between spring and summer 2008. The selection of case study areas was designed to capture differences in soil degradation processes, soil types, climatic conditions, farm structures and farming practices, institutional settings and policy priorities. A harmonised methodological approach was pursued in order to gather insights from a range of contrasting conditions over a geographically diverse area. The case studies were carried out by local experts to reflect the specificities of the selected case studies.

The mission of the Joint Research Centre is to provide customer-driven scientific and technical support for the conception, development, implementation and monitoring of European Union policies. As a service of the European Commission, the Joint Research Centre functions as a reference centre of science and technology for the Union. Close to the policy-making process, it serves the common interest of the Member States, while being independent of special interests, whether private or national.

LF-NJ-24131 EN-C

ISBN 978-92-79-14959-7